Chapter 3
Watershed Profiles

Developing a basin management plan requires understanding the nature and characteristics of the basin with which you are working. This chapter of the plan presents profiles of the Clark Fork River basin and each of its six watersheds. The profiles provide information describing the physical availability of water and address issues related to the legal availability of water.

Information presented in this chapter is based on currently available information and data that vary in age, accuracy, and depth. Gaps in information and knowledge discovered during development of the profiles are discussed at the end of this chapter.

Overview of Clark Fork River Basin

The Clark Fork River basin covers most of Montana's portion of the Columbia River basin, which drains the mountains and valleys of Montana west of the Continental Divide. It is a headwaters basin, meaning that almost all of the water leaving the basin originates within the basin.

For the purposes of this plan, the Clark Fork River basin has been divided into six smaller watersheds: Flathead River, Bitterroot River, Blackfoot River, Upper Clark Fork River, Middle Clark Fork River, and Lower Clark Fork River. Each of the watersheds is defined by the USGS gaging station that measures flows at its outlet point. Table 3.1 presents a brief description of each watershed, its sub-basins, and the gaging station used to define its outlet.

Figure 3-1

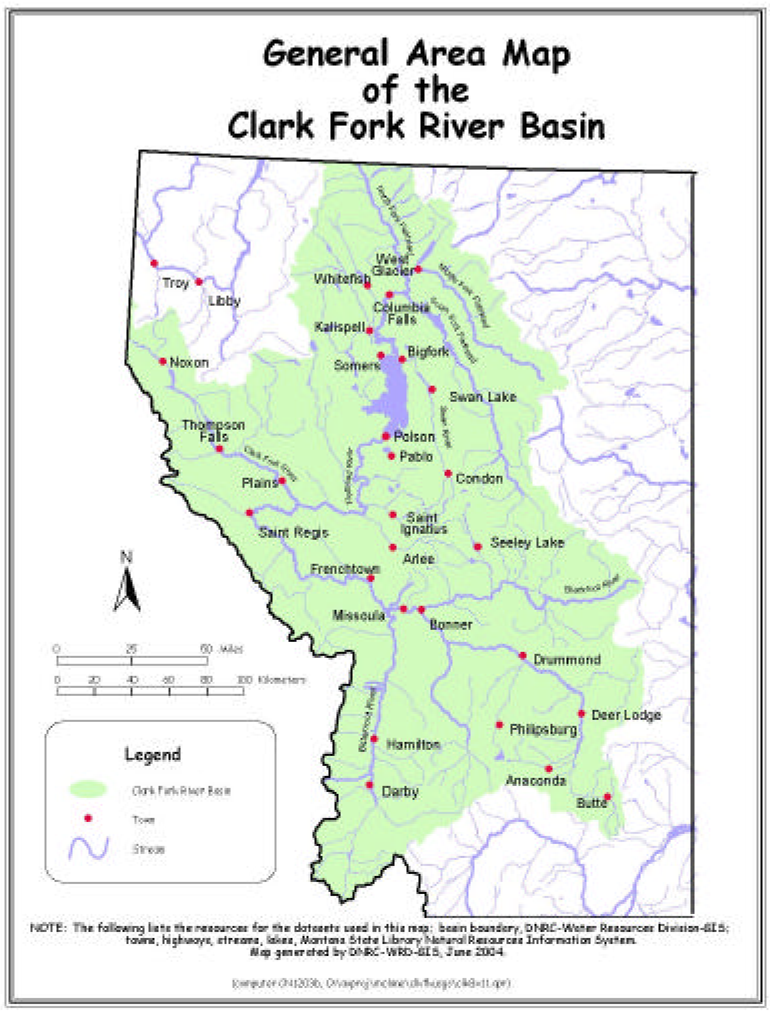


Table 3-1 Watersheds of the Clark Fork River Basin

Watershed	Description	Sub-Basins	Representative USGS Gaging Station
Flathead River	Flathead River above confluence with Clark Fork River	• North-Fork Flathead, Stillwater, Flathead Lake (76LJ) • Middle Fork Flathead (76I) • South Fork Flathead (76J) • Swan (76IL) • Lower Flathead (76L)	12388700 Flathead River at Perma
Bitterroot River	Bitterroot River above confluence with Clark Fork River	• Bitterroot (76H)	12352500 Bitterroot River near Missoula
Blackfoot River	Blackfoot River above confluence with Clark Fork River	• Blackfoot (76F)	12340000 Blackfoot River near Bonner
Upper Clark Fork River	Clark Fork River above confluence with Blackfoot River.	• Flint-Rock (76E, 76 GJ) • Upper Clark Fork (76G)	1234550 Clark Fork at Turah, Mt
Middle Clark Fork River	Clark fork River from its confluence with Blackfoot River to confluence with Flathead River	• Middle Clark Fork (76M)	12354500 Clark Fork at St. Regis
Lower Clark Fork River	Clark Fork River below confluence with Flathead River.	• Lower Clark Fork (76N)	12391400 Clark Fork below Noxon Rapids Dam near Noxon

Physical Availability of Water in the Clark Fork River Basin

Precipitation and Surface Water

The Clark Fork River near the Idaho border is the largest stream in Montana.[1] The physical availability of water in the basin is a function of a combination of natural and human factors. Climate and precipitation, geology, local and regional hydrology, and, of course, water use practices all affect the physical availability of water at any given point in the basin and in the basin as a whole.

Naturally, precipitation, geology, and drainage basin size are the major factors that determine the physical availability of water in the basin. The climate in the Clark Fork River basin is strongly influenced by moist air masses from the Pacific Ocean. This condition produces relatively abundant precipitation and mild winters compared to the rest of Montana, with occasional extended cold periods in winter and hot, dry periods in summer.[2] Precipitation in the Upper Clark Fork watershed averages around 28 inches a year, ranging from a low of less than 14 inches per year in the valleys to a high of over 100 inches per year in the mountains.[4]

The range in annual precipitation is reflected in the range of annual streamflows. Water leaving the basin is measured by the USGS gage in the Clark Fork River near Noxon. Here, annual streamflows have ranged from a low of 11,380 cfs in 1971 to a high of 31,979 cfs in 1997.[27] Over a 40-year period, the annual flows at this point averaged 20,504 cfs or 14,818,240 acre-feet.

Table 3-2 presents the average annual precipitation, drainage and watershed areas, and average annual streamflow for each watershed within the basin. Streamflows presented for the Lower Clark Fork River watershed represent the flows leaving the Clark Fork River basin.

Table 3-2 Watershed Precipitation, Area, and Streamflows

Watershed USGS Gage	Average Annual Precipitation[31] (inches)	Drainage Area[27] (sq miles)	Watershed Area (sq miles)	Average Annual Streamflow[27]		
				(cfs)	(af)	(years of record)
Flathead River 123887000	37.35	8,795	8,795	11,505	8,314,664	1984-2003
Bitterroot River 12352500	33.23	2,814	2,814	2,193	1,584,881	1990-2003
Blackfoot River 12340000	29.53	2,290	2,290	1,573	1,136,807	1940-2003
Upper Clark Fork River 12354500	28.11	3641	3641	1,206	873,300	1985-2003
Middle Clark Fork River 12354500	28.11	10,709	1,108	7,352	5,313,290	1911-2003
Lower Clark Fork River 12391400	36.79	21,833	2,329	20,504	14,818,240	1961-2000

The mountainous terrain and northern latitude of the basin combine to form snow-dominated precipitation and runoff regimes. This means that the majority of precipitation in the basin falls as snow in winter and early spring, with streamflows peaking in early summer after snowmelt has occurred. Low flows occur in early fall after the dry summer and in late winter before snowmelt has begun.

Natural streamflow patterns are affected by the cumulative impacts of all water uses occurring upstream. In many tributaries and in the upper reaches of the Clark Fork main stem, irrigation can dramatically reduce streamflows in the summer months, sometimes combining with natural factors to nearly deplete smaller streams in dry years. Depending on water use practices and local physical features, return flow from used water, especially flood irrigation, can augment late season natural flows. The construction of reservoirs, which capture part of the spring runoff and then release those waters later in the season, has further modified the basin's hydrology. Hungry Horse Reservoir and Kerr Dam (Flathead Lake) are the most significant. (The cumulative affect of such reservoirs in the greater Columbia River basin has significantly altered the natural hydrograph. Waters from Montana reservoirs are now currently released early in the season to mitigate these affects.)[3]

The Clark Fork River basin is also home to numerous ponds, lakes, and reservoirs. The basin contains 21 reservoirs with capacities greater than 5,000 acre-feet.[4] These reservoirs were constructed to provide water for irrigation, hydropower, and municipal water supply, and for flood control, but they also provide a means of regulating downstream flows. The largest of these are Hungry Horse reservoir on the South Fork Flathead River at almost 3.5 million acre-feet capacity, Flathead Lake on the Flathead River at 1.8 million acre-feet capacity, and Noxon Rapids on the Clark Fork at almost 500,000 acre-feet capacity.

Groundwater

Groundwater use within the Clark Fork River basin generally occurs within valleys filled with unconsolidated or poorly consolidated deposits between mountain ranges composed of relatively impermeable bedrock. The deposits in these valleys range from several hundred to several thousand feet thick. The valleys have perennial streams with recent floodplains adjacent to glacial deposits that extend up the mountain fronts. Often these mountain fronts are associated with faults or fault systems.[5]

Groundwater supplies in the Clark Fork River basin come from two basic types of aquifers: basin fill aquifers and fractured bedrock aquifers. Basin fill aquifers are typically found in valleys and can be either shallow and unconfined or deep and confined. These aquifers range from being very limited in extent and productivity, to highly productive and dependable. Fractured bedrock aquifers generally occur around valley margins and have relatively small water storage capacities with variable and typically low yields.[6]

Aquifer water supplies are recharged through the infiltration of water from precipitation, snowmelt, excess irrigation water, canal leakage, surface water streams, and other aquifers. An aquifer's water supply can be diminished by discharge to streams, evaporation, and withdrawals from pumping.

The largest uses of groundwater in the basin are for irrigation and public water supply, but most water for irrigation comes primarily from surface water sources. Most households in the basin rely on groundwater from wells or springs.[5]

Groundwater is growing in importance as a source of water supply in the basin. There are currently records of more than 58,000 wells in the Clark Fork River basin, 40% of which have been installed since 1990.[6] DNRC's water rights database identifies nearly 67,000 uses of groundwater in the basin. Of these, nearly 56,262 (97%) were developed after 1970. This reflects the changing land use trends, growth, and, to a decree, changes in water right record keeping process. Domestic, urban, and municipal uses—which are year-round rather than seasonal—account for 57% of these groundwater uses.

Surface water – Groundwater Interconnections

When surface water and groundwater are hydraulically connected, water can travel between a stream or other surface water body and the surrounding groundwater. For example, in a "losing reach" of a stream, the stream tends to leak water into the groundwater. In a "gaining reach," groundwater tends to seep into the stream. Aquifers act as natural storage sources that are recharged annually in varying degrees. Except for spring runoff, the majority of water in the streams of western Montana comes from groundwater discharge. Discharge to the streams is controlled by the water pressure or "head" in the aquifer. Reduced head results from withdrawal by wells and reduced recharge. Reduced head in the aquifer results in lower stream flows.

<u>Pumping</u>

Water uses can affect natural surface water-groundwater flow patterns in several ways. One way is by pumping water out of an aquifer that is hydraulically connected to a stream. About 40% of the wells in the Clark Fork basin tap into shallow alluvial (basin fill) aquifers and are located within one mile of a stream. For example, most of the wells in the Missoula Valley are developed in a highly productive aquifer that is recharged by the Clark Fork and Bitterroot rivers. Pumping these wells will intercept some of the groundwater that would otherwise discharge from the shallow aquifer to the stream. Depending on the location of a well, if pumping occurs hard or long enough, the water can actually be drawn from the stream and through the shallow aquifer to the well.[29]

<u>Return Flows</u>

Another way water use can affect surface water-groundwater interconnections is through irrigation return flows. Some portion of the water that is pumped from groundwater or diverted from surface water for irrigation will seep down through the soil profile and into the underlying groundwater. Seepage can occur through the sides and bottoms of irrigation ditches and canals or through the soil profile of irrigated fields. Seepage losses are greater through unlined conveyance systems and with flood-type irrigation systems where application of water in excess of plant consumption is common. Seepage water that makes it way back to a stream through the groundwater is called return flow. Though irrigation diversions reduce streamflows at the point and time of diversion, return flows augment streamflows further downstream and later in the year.

Though seepage water is considered a loss from the standpoint of the irrigator, this water is not consumed so it is not lost to the basin. Seepage water that stays in the groundwater is available for others to pump. In some aquifer systems, irrigation seepage is an important source of aquifer recharge. Water levels in these aquifers increase during the irrigation seasons and subside again during fall and winter.

Water supply shortages and the desire to increase crop production have led irrigators to take measures to increase irrigation efficiency. Increases in efficiency can be gained through lining ditches and canals, replacing ditches and canals with pipeline, and switching from flood-type to sprinkler-type irrigation systems. Increasing irrigation efficiency results in decreasing water diversions and seepage losses, which in turn decreases irrigation return flows. It is important to note that hydrologists use different definitions of return flows, waste, and seepage than is found in water law. This discussion focuses upon the physical rather than legal relationships.

Existing Appropriations of Water in the Clark Fork River Basin

Within Montana, all waters are owned by the State, but Montanans can acquire a water right that authorizes them to appropriate water to put it to beneficial use. Also, some waters were reserved by the federal government. Chapter 4 provides additional information describing the fundamentals of water rights and the legal framework for water management in Montana. This section presents an overview of existing water appropriations in the Clark Fork River basin.

Table 3-3 Water Use Appropriations in the Clark Fork River Basin[7]								
Clark Fork of Columbia Basin,			**Surface & Ground Water Use From Water Rights**					
			Development Dates (Priority Dates)					
Purposes	**Purpose code**	**Total**	**Pre 1910**	**Pre 1950**	**Post 1910**	**Post 1950**	**Post 1970**	**Unknown**
Augmentation	AG	1	0	0	0	0	0	0
Agricultural Spraying	AS	18	1	2	5	4	1	1
Commercial	CM	1,933	29	177	1,411	1,263	1,046	4
Domestic	DM	38,691	748	3,368	37,847	35,227	31,811	96
Erosion Control	EC	2	0	0	2	2	1	0
Flood Control	FC	3	1	1	2	2	2	0
Flow Through Fish Pond	FF	2	0	1	2	1	1	0
Fire Protection	FP	140	32	51	108	89	41	0
Fish Raceways	FR	81	26	43	55	38	14	0
Fishery	FS	219	16	23	203	196	196	0
Fish and Wildlife	FW	1,027	138	315	884	707	572	5
Geothermal	GE	39	1	3	38	36	36	0
Geothermal Heating	GH	23	0	0	23	23	23	0
Industrial	IN	439	96	161	335	270	157	8
Irrigation	IR	17,115	7,097	9,849	9,838	7,086	5,218	180
Institutional	IS	160	28	58	132	102	68	0
Irrigation – Lawn and garden	LG	11,067	67	320	10,996	10,743	10,278	4
Municipal	MC	336	36	96	292	232	160	8
Multiple Domestic	MD	1,306	12	38	1,294	1,268	1,214	0
Mining	MN	482	223	325	258	156	96	1
Navigation	NV	2	0	1	2	1	0	0
Other Purposes	OP	90	1	1	89	89	88	0
Observation and Testing	OT	15	1	2	14	13	8	0
Pollution Abatement	PA	12	2	3	10	9	8	0
Power Generation	PG	145	29	69	114	74	50	2
Power Generation - Non consumptive	PN	6	5	6	1	0	0	0
Recreation	RC	611	66	285	543	324	271	2
Storage	SG	12	0	9	11	2	0	1
Sale	SL	1	0	1	1	0	0	0
Stock water	ST	18,500	4,809	8,043	13,600	10,366	8,857	91
Wildlife	WI	208	20	195	188	13	12	0
Wildlife & Waterfowl	WW	110	2	2	108	108	108	0
Other	XO	26	2	3	24	23	15	0
	Grand Total	92,822	13,488	23,451	78,430	68,467	60,352	403
Summary Similar Uses								
Domestic	(DM &MD)	39,997	760	3,406	39,141	36,495	33,025	
Gen. Municipal	(MC, In, IS,CM)	2,868	189	492	2,170	1,867	1,431	
Irrigation	(IR & LG)	28,182	7,164	10,169	20,834	17,829	15,496	
Agricultural all	AS,IR,ST	28,200	7,165	10,171	20,839	17,833	15,497	
Wildlife	(FF,FR,FS,FW,WI,WW)	1,647	202	579	1,440	1,063	903	
Power Gen.	PG,PN	151	34	75	115	74	50	

As of June of 2004, Montana's centralized water right records system identified water rights for 92,822 water uses in the Clark Fork River basin.[7] Of these uses, nearly 28% were from surface water sources and 72% from groundwater. Agricultural uses account for over 30% of the total basin water uses. Looking only at surface water uses, 75% are for agricultural purposes, with irrigation representing almost half. A listing of the number of water uses in the basin by water use category and by period of development is presented in Table 3-3.

Diversionary Water Uses

Montana recognizes many different beneficial water uses. It is important to note that water right law and water quality law have at first glance similar legal definitions of "beneficial uses," but in application are considerably different. Historically, Montana water law required all uses to have "control" over the water. Control typically implied the use of a diversion device (head gate). Statutory law and court case law have both refined and expanded these definitions to include instream use and instream flows as a beneficial use for which a water right can be obtained.

Diversionary water uses are those that divert or pump water away from its source and consume all or a portion of the water as part of the beneficial use. Diversionary uses include irrigation, residential or domestic, and municipal uses.

Irrigation

Irrigation is the largest consumptive water use in Montana,[8] accounting for 97% of the total estimated water withdrawals and 93% of the total estimated water consumption.[25] About 15% of Montana's cropland and pastureland is irrigated. Close to 80% of the irrigated acres are in hay and pasture forage.[9] Nearly 40% of all irrigated lands in the Clark Fork River basin are located in the Flathead River watershed. The distribution of irrigated acreage in the Clark Fork River basin is illustrated in Table 3-4.

Data describing the number of irrigated acres across the state varies, sometimes dramatically, with the source of information. According to land cover data provided by NRIS, approximately 262,000 acres within the Clark Fork River basin[10] are irrigated. According to a DNRC report, however, irrigation upstream of Noxon Rapids Dam totaled 358,000 acres in 1950 and 427,000 in 1980.[11] In 1991, the publication "UCAO-Clark Fork/Flathead Basin Irrigated Lands" by the USDA Bureau of Reclamation was released for use in planning process. Developed through the interpretation of satellite imagery, the UCAO report identifies 471,000 acres of irrigated lands in Montana's Clark Fork basin. These acreages are displayed in the table below.[12] The Task Force has opted to use number of irrigated acres from this report because it is the newest data set consistent with past inventories. The Task Force also recognizes its value and limitations as a planning tool. This data set may over estimate irrigated acreages.

The Montana water right database contains 28,182 water right records for irrigation water use within the basin, including 12,523 from surface water and 15,650 from groundwater. Irrigation accounts for 30% of the total 92,800 water right uses of record. Lawn and garden irrigation accounts for 11,067 developments, including 527 from surface water and 10,540 from groundwater. The remaining 17,115 developments are for traditional agricultural irrigation. A 1998 analysis of DNRC's water right database identified 149 irrigation water right records (from surface and groundwater sources) that have a diversionary rate greater than 5 cfs. Combined, these 149 water right records assert rights to irrigate a total of 61,188 acres, which is roughly 13% of the total irrigated acreage in the basin.[13]

Most irrigation diversions are not measured, so data are not available to determine accurately the amount of water diverted and consumed by irrigation. However, estimates of irrigation diversions and water consumption can be developed based on estimates of the number of irrigated acres, irrigation consumptive uses, and irrigation efficiencies. For example, we can estimate that if all of the 470,980 irrigated acres in were fully irrigated, roughly 2,116,000 acre-feet of water would be diverted and 1,058,000 acre-feet would be consumed by irrigation in the basin each year. (Annual crop consumption varies geographically and for these calculations ranged from 1.92 acre-feet per acre in Lake County to 2.48 acre-feet per acre in Ravalli County.) The irrigation period of use also varies between basins. Numerous geographic, climatic, and agricultural factors affect when irrigation occurs. On average, the irrigation season begins in mid April and ends in mid September. However, in unusual years some irrigation occurs both earlier and later than these averages. If this water were pumped continuously over a 150-day irrigation season, irrigation water uses would divert 7,115 cfs and consume 3,560 cfs. Irrigation water use, however, is not consistent over the season. Table 3-4 estimates monthly irrigation consumptive water use for each watershed that would occur if all the reported 470,980 irrigated acres in the basin were fully and consistently irrigated.

Table 3-4 Irrigated Acreage and Estimated Irrigation Consumptive Uses

Watershed	Irrigated Lands[10] (acres)	Estimated Irrigation Consumptive Uses (acre-feet)					
		Total	May	Jun	Jul	Aug	Sep
Flathead	182,800	350,062	13,710	73,425	141,670	108,461	12,491
Bitterroot	93,950	233,153	19,730	52,455	79,858	65,765	15,345
Blackfoot	44.280	108,338	8,118	23,616	37,712	31,217	7,675
Upper Clark Fork	121,000	296,047	22,183	64,533	103,052	85,305	20,973
Lower Clark Fork	28,950	70,831	5,308	215,440	24,656	20,410	5,018
Clark Fork River Basin Total	**470,980**	**1,058,431**	**69,048**	**229.469**	**386,947**	**311,158**	**61,503**

Irrigation is considered to be a consumptive use of water, but, as described above, only a portion of the water diverted or pumped for irrigation is actually consumed by plants and evaporation. Some of the water diverted or pumped for irrigation returns to the stream directly and relatively quickly as carriage water or surface runoff, and some returns indirectly and more slowly through groundwater as return flows. Though the types and combinations of conveyance and irrigation systems vary dramatically across the basin, roughly 50% of the water diverted for irrigation is consumed by evaporation and evapotranspiration.[14,22] The amount and timing of irrigation water recharging groundwater or returning to streams is significant for water management, but water rights records do not quantify the discrepancy between diversion and consumption. This component of the basin's water budget has been researched in some portions of the basin both recently and in the 1960s, but has not been examined in many portions of the Clark Fork basin.

<u>Residential and Municipal</u>

Although irrigation is the largest user of water in Montana, domestic and municipal water use is increasing and in some sub-basins represents a greater total water use than irrigation.[15] The Montana water rights database includes 42,865 records for municipal uses in the Clark Fork River basin, including domestic, multiple domestic, industrial, institutional, commercial, and similar urban water demands. The majority of communities and individual residences in the basin, about 38,500, use groundwater as their primary source of water.[16] A few, 4,350, rely heavily on surface water sources. Per capita water use varies by season, with most communities using significantly more water in the summer months. Per capita water use varies by community, ranging from approximately 140 gallons per day (gpd) in Lake County up to about 400 gpd in Missoula County.[8]

Domestic and municipal water uses are considered consumptive uses, but, as with irrigation, only a portion of the water diverted or pumped is actually consumed. In urban areas, much of the water diverted for domestic and municipal use is returned to surface water as wastewater discharge. In rural areas with no centralized wastewater treatment, much of the supply water is returned to the basin as septic system discharge, a portion of which seeps to underlying aquifers. Systems vary significantly, but roughly 70% of the water diverted for domestic and municipal uses returns to the basin through surface or groundwater.

In Kalispell, approximately 73% of the water pumped for municipal supply from the deep artesian aquifer is discharged to Ashley Creek. Additional water is returned via urban runoff, system leakage, and infiltration from yard irrigation. According to the USGS, 90% of domestic water is returned to the environment.

Non-Diversionary Uses

Non-diversionary uses of water are those that use water in the stream channel as part of the beneficial use. In this plan, hydropower is included with instream flows as a non-diversionary use even though dams do divert and control water flows. The volume and flows associated with these non-diversionary uses can significantly limit new diversionary uses in or above the affected stream reach.

Table 3-5 Hydropower Facilities in the Clark Fork River Basin

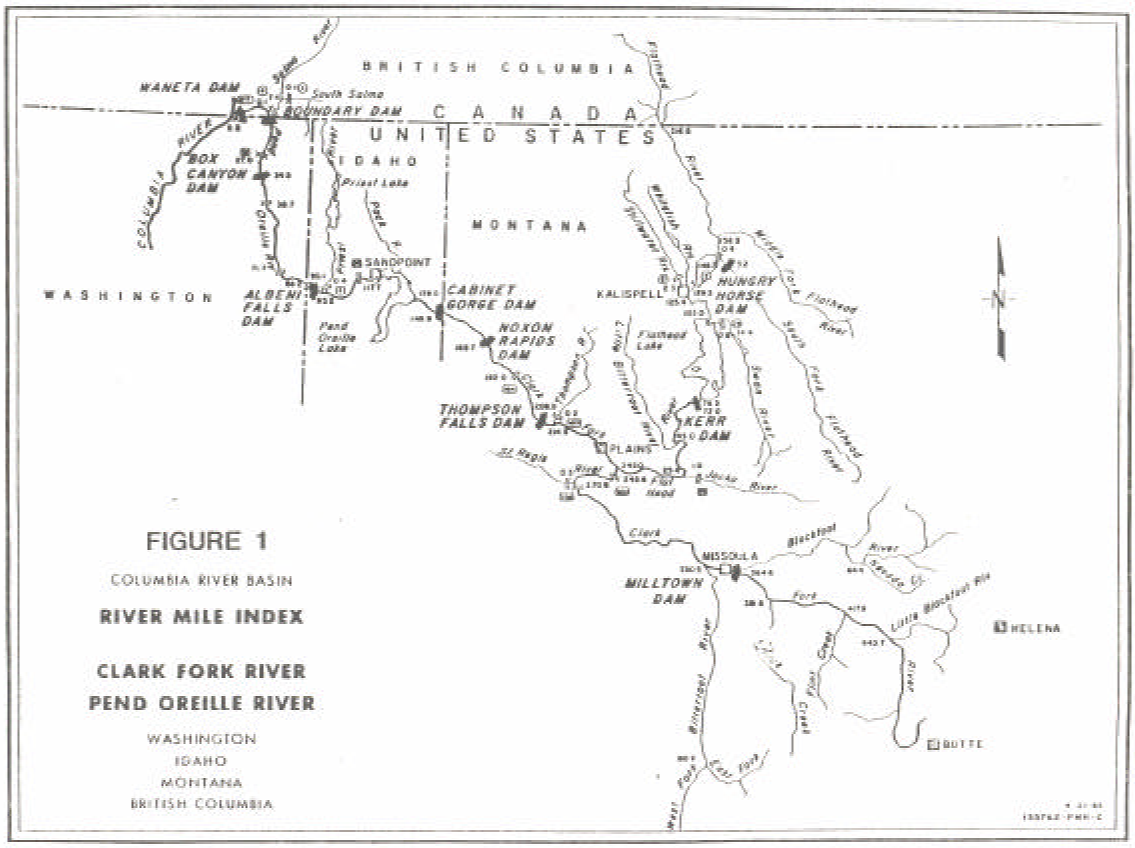
Hydropower Facility	Location[22]	Generation Capacity (MW)[22]	Turbine Capacity (cfs)	Volume of Water per year (1,000 ac-ft)	Type[22]
Hungry Horse	South Fork Flathead River	328	8,900	6,443	Storage
Kerr	Flathead River	180	14,540	10,386	Storage
Milltown	Clark Fork River	3	2,000	1,448	Run-of-River
Thompson Falls	Clark Fork River	40	23,420	16,956	Run-of-River
Noxon Rapids	Clark Fork River	554	50,000	36,200	Storage
Cabinet Gorge[1]	Clark Fork River	230	36,000	26,064	Run-of-River

[1]Cabinet Gorge Dam is located in Idaho, but most of the storage capacity provided by the reservoir lies within Montana. Cabinet Gorge's water rights were specifically subordinated to all present and future upstream water rights in Montana in exchange for the reservoir easement being granted by Montana. (See 85-1-122, MCA.)

Hydropower

There are six major hydropower facilities in Montana's Clark Fork River basin. The location of these facilities is illustrated in Figure 3-2. A list of the facilities and their capacities is presented in Table 3-5. There are also numerous smaller and privately owned generation units within the Clark Fork basin, many of which provide power for users not connected to the utility transmission grid. DNRC water right records identify a total of 151 basin hydropower water rights. Note that this does not imply 151 different projects since many developments have more than one water right. For example, the Thompson Falls facility operates under 8 separate water rights.

Figure 3-2 Hydropower Facilities in the Clark Fork River Basin



From Cunningham, A. b., M.L. Bultsma, and R. d. Boyce, 1988. Effects of Future Irrigation Development on Hydroelectric Generation in the Clark Fork River Basin. MSU-Bozeman.

Instream flows

Appropriations under the "instream flow" category refer to water that is left in the stream to protect fish, wildlife, recreational uses, aesthetic and scenic values, and water quality.[17] There are four methods of protecting instream flows in Montana: Murphy Rights, water reservations, compacts (treaties), and water leases (see Chapter 4 for more information).

Murphy Rights were established by the Montana legislature in 1969 to provide a mechanism to help protect streamflow amounts necessary for the preservation of fish habitats. Murphy Rights date back to 1970 and protect flows only when senior water rights have been satisfied. There are 5 stream reaches within the Clark Fork River basin with Murphy Rights.[18]

As of 1998, 1,647 records specify a fish and wildlife use, but the database does not differentiate between instream use for protection of fisheries, water diverted for fish and wildlife ponds, or water developed for recreational or aesthetic purposes. The majority of these records are for diversionary uses. There are a wide variety of beneficial uses that fall within these categories. They include fish ponds, fish raceways, wildlife water developments, augmented wetlands, wetland mitigation, and waterfowl and wildlife refuges.

Water reservations for instream flow and future uses of water have not been developed in western Montana. Montana law allows most public entities to apply for a water reservation. Water reservations developed under state law allow the appropriator to claim and protect for future consumptive uses, the protection of instream flows, or protection of lake levels.[19] In both the Yellowstone and Missouri basins, the state has supported and initiated a water reservation process. A similar effort was begun but not completed in the Upper Clark Fork. The process became contentious and was resolved through other mechanisms.

The Montana water rights database also does not indicate if an appropriation has been leased for instream flows. However, recent research identified 20 water leases developed under the private leasing program/changes of use statutes, including 5 in the Clark Fork basin. The Montana Department of Fish, Wildlife and Parks (DFWP) leasing program has negotiated an additional 7 leases in the Clark Fork basin.

The assessment of existing appropriations in the basin is complicated by the unquantified federal reserved water rights that are discussed in Chapter 4. The federal reserved water rights claims of the Confederated Salish and Kootenai Tribes (CSKT) on and potentially off of the Flathead Reservation are of particular significance in the Clark Fork basin. The CSKT claim rights not only on the reservation, but also for fishing and hunting off the reservation (instream flows) everywhere in Montana west of the continental divide. These tribal water rights and hunting and fishing rights are likely to be senior to those to most of the basin's water uses. In other words, it is conceivable that CSKT may be able to develop and consume additional water at the expense of existing water users, or to commit a greater share of their rights to instream flow protection. When the water rights of CSKT are eventually quantified, they will have an enormous impact on the legal availability of water to present and future water users.[20]

The U.S. Forest Service and the State of Montana are currently negotiating the extent of the federal reserved rights associated with national forests as well as mechanisms to protect the interests of private water users. Instream flows appear to be included in these negotiations. At this point, these rights are unquantified.

Water Available for Future Use in the Clark Fork River Basin

Determining how much, if any, water is available for future use from a given local stream or aquifer is addressed by existing water law. To obtain a new water use permit, an applicant must prove that unappropriated water is available from the proposed source at the proposed point of diversion for the new use and that the new use will not adversely affect existing water rights holders with water rights on the proposed source. Though the concept of adverse affect is based on historic case law and is often complex and highly source specific, hydrologic analyses can be used to illustrate how much water is physically available from the proposed source and what the local impact of the new use might be. In response to increasing numbers of conflicts among existing users or objections to new uses, the state can establish some form of basin closure (see Chapter 4).

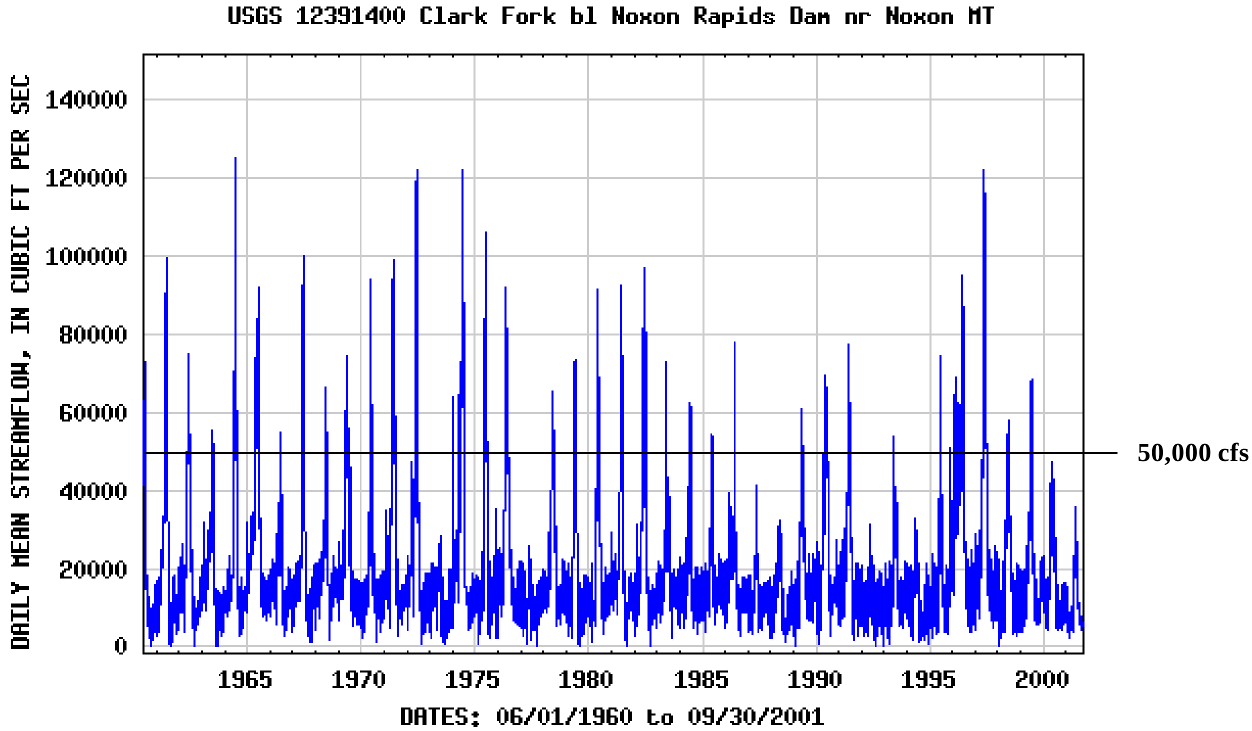
In recent decades, however, concern has increased that the cumulative impacts of numerous individual upstream water users in a basin have a significant potential to affect downstream water rights, and particularly those held by hydroelectric facilities.[21] Results of basin modeling efforts by Cunningham et al.[22] indicated that for those hydropower facilities with significant reservoir storage (Kerr and Noxon Rapids, for example), increased upstream irrigation led to slightly decreased power production, and that increased flood irrigation decreased energy production to a greater extent than increased sprinkler irrigation. Power generation at run-of-river facilities showed very slight impacts from increasing upstream irrigation and the impacts varied with total amount and system type.

Due to its location and capacity, Noxon Rapids Dam, operated by Avista Corporation under a license from the Federal Energy Regulatory Commission, may pose the greatest single limitation to water available for future use in the Clark Fork River basin. Avista's water rights for 50,000 cfs of flow at Noxon Rapids are of sufficient size to utilize almost all of the flows leaving the basin.[23] Noxon's most junior priority date is 1974.

Even with this right in place, as of June 2004, 60,352 of the water rights in the basin (approximately 65% of all the recorded water uses in the basin), were issued after 1970. Groundwater sources service most of these rights (56,260). Nearly 5,500 rights utilize surface water. Many of these post-1970 water uses do not divert a significant amount of water but are likely to be of critical importance to the individual users. Approximately 33,000 post-1970 uses are for domestic purposes, with 31,800 served from groundwater. Assuming they divert about 1.5 acre-feet each annually, total use would be about 50,000 acre-feet. For this period, 157 uses are for industrial purposes. Traditional irrigation accounts for 5,200 of the post-1970 uses, with 73% supplied by groundwater (see Table 3-3). Of the basin's roughly 12,000 traditional irrigation water rights, the 9,100 rights that historically both diverted and consumed the greatest quantity of water were developed prior to 1950 and therefore are senior to the Noxon Rapids Dam hydropower rights. Slightly more than half of these irrigation rights (6,850) pre-date 1910 and the Thompson Falls earliest and most senior hydropower right.

One way to determine how much, if any, water might be available for future uses in the basin is to consider how often the flows at Noxon Rapids dam exceed 50,000 cfs. An analysis of flows occurring at the dam conducted by DNRC[24] indicated that, on average, flows at Noxon exceed 50,000 cfs approximately 30 days per year, typically in the months of May and June. In wetter years (those years with flows that are exceeded in 3 out of every 10 years) there is an average of 21,320 cfs available between May 25 and June 17. In drier years (those years with flows that are exceeded in 8 out of every 10 years), no excess water is available. This analysis suggests that though water may be physically available for new uses throughout the basin, water is only legally available in 3 out of every 10 years and then only for a 30-day period in the spring. It also suggests a potential solution to the problem. Development of additional storage capacity would offer additional benefit to Avista and a probable opportunity to amend or forego a call on the river. Figure 3-3 compares the average daily flows of the Clark Fork River below Noxon Rapids Dam to the 50,000 cfs water right claimed by Avista at the dam.

Figure 3-3 Average Daily Flows on the Clark Fork River below Noxon Rapids Dam



Projected Demand for Future Water Use

Currently, the two greatest uses for water in the basin after hydropower are for irrigation and municipal/domestic purposes. Throughout the basin, trends indicate limited growth potential for new irrigation and increasing demands for municipal and domestic uses in the future.

Irrigation Water Use

Data describing historically and currently irrigated acres and irrigation water use in the basin are inconsistent and unreliable. For this reason, it is difficult to make projections regarding demands for future irrigation water use.

Available data indicate that the number of irrigated acres in Montana has increased by around 48,000 acres since 1992, and most of these acres are irrigated by surface water.[25] Analysis of the Montana water rights database indicates that the number of appropriations for irrigation water uses in the Clark Fork River basin increased from 11,405 in 1976 to 12,651 in 1998. This represents in increase in the number of irrigation water uses of about 10% over a 22-year period, or less than 0.5% per year. It is unknown, however, how many of these new appropriations might represent conversions from surface water sources to groundwater sources. Though such conversions are possible through water right changes, it is common in these situations for users to apply for permits for groundwater when their surface water source becomes unreliable.

Unlike residential development, distinct physical constraints limit the potential for increasing the number of irrigated acres in the basin. Most of the irrigable land that can be easily served by gravity diversion in Montana has already been developed; however, it is estimated that an additional 11.5 million acres of land in the state could be irrigated if a supply of water was physically and economically available.[9] Data describing the number of potentially irrigable acres remaining in the Clark Fork River basin are not available.

Though additional irrigable lands may exist in the basin, the trend is toward the conversion of arable land to urban and rural development. The number of acres of agricultural land in Montana converted to urban/rural development increased significantly from 1982 to 1997. Urban and rural development acres were up from approximately 879,000 acres in 1982 to more than 1 million acres in 1997, an increase of almost 15%. More than one-third of the newly developed land was historically native rangeland. Land historically in forest and pasture accounted for almost one-third of the conversion to developed land, followed by a lesser amount of cropland.[25]

The report included in Appendix 3 indicates that basin agriculture producers are struggling to survive because costs exceed cash receipts. This fact implies that significant expansion of irrigated acreage is unlikely.

Municipal and Domestic Uses

U.S. Census data for 1990 and 2000[26] indicate that the population in the basin has grown at rates between 1% and 3% a year. Overall, the population of the basin has grown from 266,014 in 1990 to 316,188 in 2000, which represents a change of 19% or an average of 2% per year. Growth rates in the basin vary by watershed, with the Bitterroot River and Flathead River watersheds showing the greatest increase, and the Upper Clark Fork River watershed showing the least. Table 3-6 illustrates the change in population over the 1990 to 2000 period. This information is discussed in greater detail in Appendix 3.

Table 3-6 Population in the Clark Fork River Basin for 1990 and 2000

			% increase	
Watershed	**1990**	**2000**	**10-year total**	**average annual**
Flathead River	90,021	111,131	23%	2.35%
Upper Clark Fork River	107,708	118,736	10%	1.02%
Lower Clark Fork River	7,769	8,811	13%	1.34%
Bitterroot River	54,546	70,743	30%	2.97%
Blackfoot River	5,970	6,767	13%	1.34%
Clark Fork River Basin	**266,014**	**316,188**	**19%**	**1.89%**

Per capita water use varies dramatically throughout the basin, ranging from a low of under 150 gpd in Lake County to a high of 400 gpd in Missoula County. Assuming an average growth rate of 1.89% per year, the population in the basin would grow to 375,826 people by the year 2020. Using Missoula's per capita water use as a guide, this 2020 population would use an additional 26,722 acre-feet per year or about 37 cfs. For comparison, 26,722 acre-feet represents less than 0.2% of the average annual flow leaving the basin. These estimates suggest that even with continued population growth and high per capita water use, municipal and domestic water uses do not represent a large pressure on water supplies in the basin overall. Based on historical usage, it is reasonable to assume that the majority of future residential developments will use groundwater to meet their growing water supply demands.

Flathead River Watershed

The Flathead River watershed covers 8,795 square miles of area drained by the Flathead River and its tributaries above its confluence with the Clark Fork River.[27] The lowest point of the watershed is defined by USGS gage 12388700 Flathead River at Perma.[27] This watershed is made up of seven smaller sub-basins: North Fork Flathead, Stillwater, and Flathead Lake (76LJ); Middle Fork Flathead (76I); South Fork Flathead (76J); Swan (76IL); and Lower Flathead (76L)[28].

The Flathead River watershed is defined by the Flathead River, with Flathead Lake being the most notable surface water body. Major tributaries in the basin include the North, South, and Middle forks of the Flathead River; Swan River; Jocko River; Stillwater River; Whitefish River; and Little Bitterroot River. The watershed is dominated by mountains and forests, but includes approximately 183,800 acres of irrigated lands in the valleys (USBR Remote Sensing Analysis). A map of the watershed is provided in Figure 3-4.

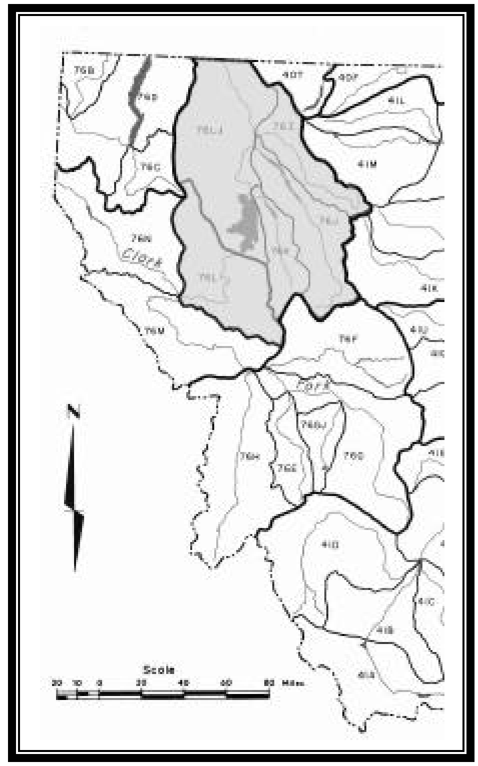


Figure 3-4 Flathead Watershed

Physical Availability of Water in the Flathead River Watershed

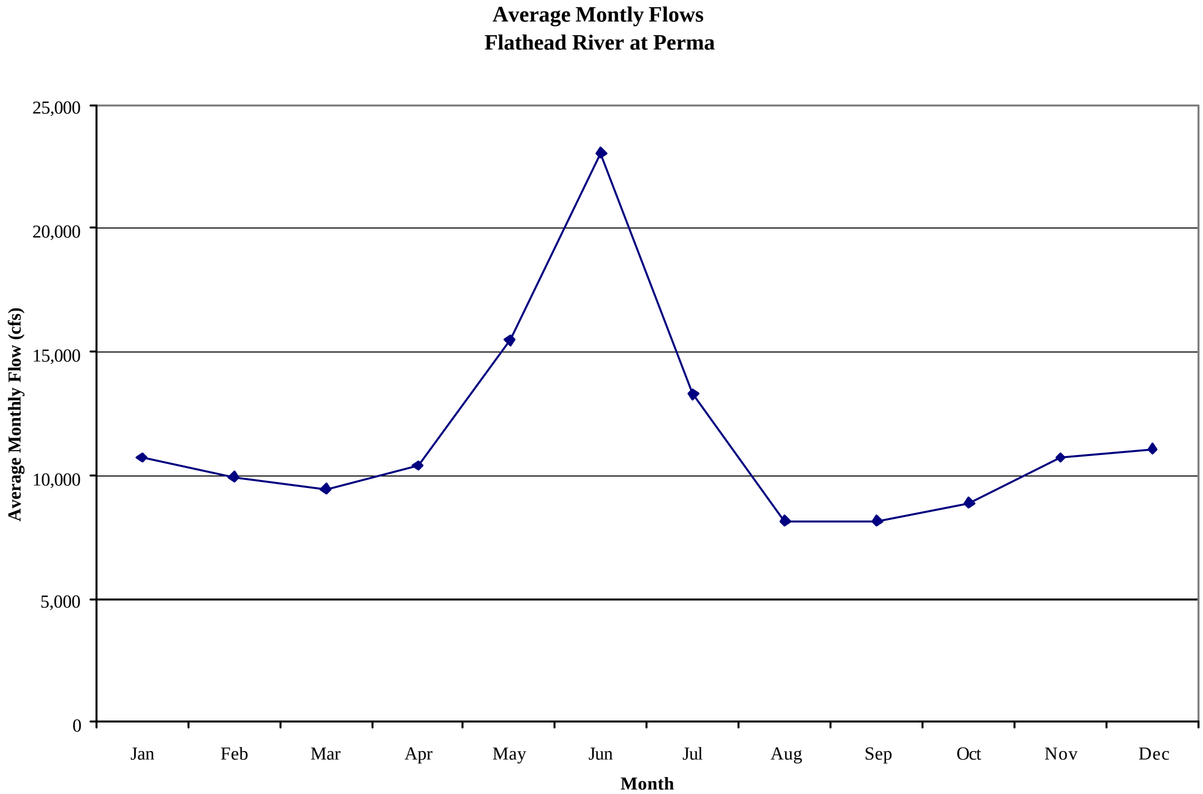
<u>Precipitation and Surface Water</u>

Precipitation in the Flathead is the highest among watersheds in the Clark Fork River basin, averaging over 37 inches per year. Precipitation amounts vary over the watershed, with significantly more precipitation falling in the mountains in the form of snow.

The Flathead River is also the largest tributary of the Clark Fork River, contributing approximately 56% of the flow in the Clark Fork River where it leaves the state. An average of 11,505 cfs (8,314,664 acre-feet) flows out of the Flathead River watershed annually. Average monthly flows at the mouth of the watershed range from a high of 23,060 cfs in June to a low of 8,157 cfs in August. Flows in the Flathead River are regulated by Hungry Horse Dam on the South Fork Flathead River and to a lesser extent by Kerr Dam just south of Flathead Lake. These reservoirs serve to reduce high flows during spring runoff and substantially increase

flows during typically low flow periods.[2] The average monthly flows of the Flathead River at Perma are illustrated in Figure 3-5. Several other small dams and reservoirs on the Swan River and Little Bitterroot River, and 17 reservoirs in the Flathead Irrigation Project affect flows locally.

Figure 3-5 Average Monthly Flows in the Flathead River at Perma



Groundwater

The aquifer systems in the Flathead River watershed are characterized by alluvial aquifers in the valleys with fractured bedrock aquifers at the valley fringes; however, the nature and combination of aquifer systems in each valley varies. The Kalispell Valley, north of Flathead Lake, has productive deep and shallow basin fill aquifers with more limited bedrock aquifers along the valley margins. The Mission Valley, south of Flathead Lake, contains thin, discontinuous basin fill aquifers that are not as productive or extensive as those in the Kalispell Valley.[29]

The Montana Bureau of Mines and Geology Ground Water Assessment Program is completing a baseline assessment of the groundwater resources of the Flathead Lake area. This assessment will include information describing the hydrogeologic framework of the area, hydraulic characteristics of the aquifers, and aquifer recharge and discharge characteristics. This program uses wells of opportunity – existing wells – and therefore the assessment has limitations.

Existing Appropriations of Water in the Flathead River Watershed

Water rights records as of June 2004 show nearly 32,000 water use appropriations within the Flathead River watershed. The breakdown of appropriations among different water uses is presented in Table 3-7 below.

Table 3-7 Water Use Appropriations: Flathead Watershed				
Purposes	**Totals**	**Post 1970**	**Ground water**	**Surface Water**
Agricultural Spraying	6	1	1	5
Commercial	794	551	686	108
Domestic	15762	12113	12984	2,778
Erosion Control	1	1	1	
Flood Control	1	0		1
Flow Through Fish Pond	1	1	1	
Fire Protection	26	9	13	13
Fish Raceways	54	11	32	22
Fisheries	93	92	50	43
Fish and Wildlife	325	206	129	196
Geothermal	17	15	16	1
Geothermal Heating	10	10	10	
Industrial	122	61	81	41
Irrigation	4,301	1,700	1,494	2,807
Institutional	15	13	15	
Irrigation - lawn and garden	3,781	3,571	3,452	329
Municipal	139	71	116	23
Multiple Domestic	701	660	663	38
Mining	8	2	5	3
Navigation	2	0		2
Other Purposes	26	26	12	14
Observation and Testing	1	1	1	
Pollution Abatement	3	2	2	1
Power Generation	50	13	9	41
Power Generation Nonconsumptive	1	0		1
Recreation	166	62	58	108
Storage	4	0		4
Stockwater	5,289	3,313	4,256	1,033
Wildlife	2	2	1	1
Wildlife & Waterfowl	20	20	4	16
Other	6	5	5	1
Total	31,,727	22,532	24,097	7,630

The vast majority of existing appropriators in the watershed are supplied by groundwater (24,000 uses). Surface water supplies more than 7,600 uses. Of these, 2,800 are for traditional irrigation.. As population in the valleys increase, new uses of groundwater also increase. For example, in the populated Flathead Lake sub-basin (76LJ), the number of residential uses of water far exceed that for irrigation.

Diversionary Uses

Irrigation

The Flathead River watershed contains approximately 182,800 irrigated acres, which represents almost 40% of the irrigated land in the Clark Fork River basin. Over 115,000 acres lie in Lake County and below Kerr Dam. Based on the assumptions presented above, if all of these acres were fully irrigated, then irrigation in the watershed would divert close to 700,000 acre-feet and consume 350,000 acre-feet of water per year. Spread over the irrigation season, this volume of water would translate to a flow of roughly 2,470 cfs in diversions and consume 1,235 cfs.

Municipal and Residential

The Flathead River watershed includes all of Flathead and Lake counties, the northern portions of Missoula and Powell counties, and the eastern portion of Sanders County. Cities in the watershed include Whitefish, Columbia Falls, Kalispell, Polson, Evergreen, and Ronan. About 111,000 people live in the greater Flathead Lake area. All of the major communities (except Whitefish) and most rural residences in the region use groundwater for municipal and domestic water supplies.[29] The deep alluvial aquifers are the most utilized and generally the most productive aquifers in the watershed. However, use of the fractured bedrock aquifers is increasing, corresponding to the increase in residential development at valley fringes.[29] The Montana water rights database indicates 18,234 water rights for municipal and domestic uses. Groundwater sources service 80% (14,545) of these municipal and domestic uses.

Non-Diversionary Uses

Hydropower

Both Hungry Horse and Kerr dams are located within the Flathead River watershed. Hungry Horse is a USBR facility located on the South Fork Flathead River that is used primarily for flood control and power generation. Kerr Dam, owned by PPL Montana (formerly owned by Montana Power Company), is located on the Flathead River just downstream from Flathead Lake, which serves as its reservoir. This facility is used for power generation, flood control, and recreation. Both of these facilities provide significant amounts of storage and serve to regulate the flows of the Flathead and Clark Fork rivers, decreasing streamflows during naturally high flow periods and increasing flows during low flow periods. Additional hydropower facilities are located at Bigfork and Big Creek.

Instream Flows

DFWP has claimed Murphy Rights on several stream reaches within the Flathead River watershed. The reaches, priority dates, periods, flows, and volumes of these claims are presented in the Tables 3-8 through 3-11. In addition to these Murphy Rights, DFWP may have additional water right claims on selected streams, creeks, ponds, lakes, reservoirs, or swamps in the watershed.

Table 3-8 Murphy Right Claims on the Flathead River (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Flathead Lake to South Fork	12/22/70	8/1 – 4/15	3,500
		4/16 – 4/30	6,650
		5/1 – 7/15	8,125
		7/16 – 7/31	5,402
South Fork to Middle Fork	12/22/70	10/1 – 3/31	1,950
		4/1 – 4/15	2,100
		4/16 – 4/30	3,597
		5/1 – 7/15	5,000
		7/16 – 7/31	3,945
		8/1 – 9/30	2,100

Table 3-9 Murphy Right Claims on the Middle Fork Flathead River (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Mouth to Bear Creek	12/22/70	8/1 – 4/15	850
		4/16 – 4/30	1,831
		5/1 – 7/15	2,325
		7/16 – 7/31	1,904
Bear Creek to Cox Creek	12/22/70	10/1 – 3/31	75
		4/1 – 9/30	180

Table 3-10 Murphy Right Claims on the North Fork Flathead River (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Middle Fork to Bowman Creek	12/22/70	10/1 – 3/31	987.5
		4/1 – 4/15	1,400
		4/16 – 4/30	1,766
		5/1 – 7/15	2,625
		7/16 – 7/31	2,041
		8/1 – 9/30	1,400
Bowman Creek to Border	12/22/70	10/1 – 3/31	625
		4/1 – 4/15	750
		4/16 – 4/30	1,100
		5/1 – 7/15	1,500
		7/16 – 7/31	1,279
		8/1 – 9/30	750

Table 3-11 Murphy Right Claims on the South Fork Flathead River (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Hungry Horse Reservoir to Powell/Flathead County Line	12/22/70	10/1 – 3/31	600
		4/1 – 4/15	700
		4/16 – 4/30	1,180
		5/1 – 7/15	1,750
		7/16 – 7/31	943
		8/1 – 9/30	700
Powell/Flathead County Line to Headwaters	12/22/70	4/1 – 9/30	270
		10/1 – 3/31	100

The assessment of existing appropriations in the Flathead River watershed, and indeed the entire Clark Fork River basin, is complicated by the unquantified prior water rights of the Confederated Salish and Kootenai Tribes (CSKT) on and potentially off of the Flathead Reservation. The CSKT claim rights not only on the reservation, but for fishing and hunting off the reservation (instream flows) everywhere in Montana west of the continental divide. Their water rights are senior to those of everyone else in the basin, and that seniority applies to their future as well as past and present uses. In other words, CSKT may want to develop and consume some additional water that could come at the expense of existing water users, or they may desire to commit a greater share of their rights to instream flow protection. Recent Montana Supreme Court decisions extended the Tribes' right not just to surface water, but also to groundwater. However the water rights of CSKT are eventually quantified, they will have an enormous impact on the legal availability of water to present and future water users.[30]

Water Available for Future Use in the Flathead River Watershed

Surface Water

As with the larger basin, water available for future use in the Flathead River watershed could be dictated by hydropower water rights. The 14,540 cfs turbine capacity at Kerr and the 8,900 cfs turbine capacity at Hungry Horse are of sufficient size to utilize all of the average annual flows of the rivers upon which they are located. The study evaluating the effects of irrigation on hydropower by Cunningham et al.[22] indicated that power generation at facilities with significant storage, such as Kerr and Hungry Horse, is reduced with increasing levels of upstream irrigation. This information suggests that water availability for new surface water development would be limited by existing hydropower water rights in the watershed. This is compounded by limitations presented by Avista's water rights at Noxon Rapids dam as discussed above. Local water shortages have led to small administrative rule closures in Walker Creek, tributary to the Whitefish River, and Truman Creek, tributary to Ashley Creek.

Groundwater

A preliminary water use study of the Upper Flathead Basin by RLK Hydro[15] indicated that unappropriated water exists in all four sub-basins within the watershed. The study also found that 98% of existing appropriations, by volume, are for surface water including hydropower, instream flows, and consumptive uses. Future appropriations are likely to emphasize development of groundwater resources. Information collected by MBMG suggests that sufficient water is available to allow for continued development of shallow aquifer systems in the watershed, but that these resources are susceptible to contamination. The deeper aquifers also appear to contain sufficient water for continued development, but they are becoming more vulnerable to drought.[36]

Projected Demand for Future Water Use in the Flathead River Watershed

Municipal and Residential

Population growth in the Flathead area has been significant, averaging 2.4% a year over the past 10 years. The population of the area is currently over 111,000 people and is expected to continue growing into the foreseeable future. If the population continues to grow at its current rate, then the Flathead River watershed will have a population of over 137,000 people by the year 2020. At the relatively high water use rates exhibited in Missoula County (400 gpd), the added population would require an additional 11,677 acre-feet of water per year, which would translate into a flow rate of about 16 cfs. The preliminary water use study by RLK Hydro[15] indicated that future appropriations for residential uses are likely to emphasize development of groundwater resources.

Irrigation

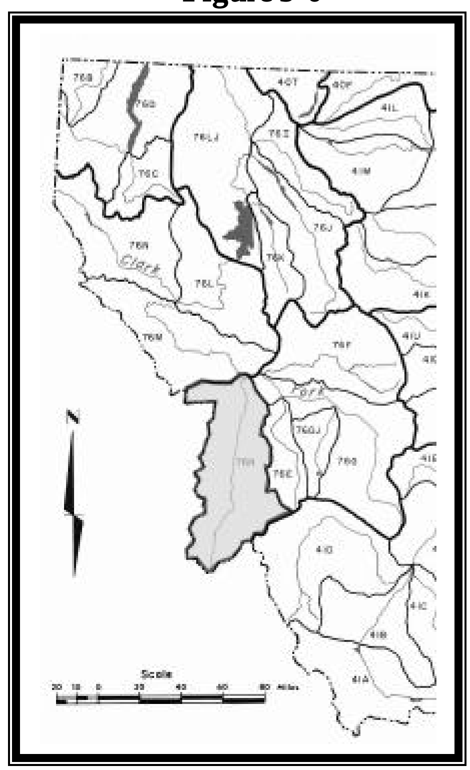
The RLK study indicated that all of the potential agricultural soil is located in the Central Flathead River Valley, an area of 270,000 acres. Currently the basin contains approximately 179,000 irrigated acres. The percentage of the remaining un-irrigated agricultural lands that could be logistically or economically irrigated is unknown. The RLK study found that the rate of new appropriations for agriculture have been declining for approximately 20 years. DNRC records indicate that agricultural development, in terms of number of rights being developed, has been in the range of 1,000-2,200 new uses per decade during the period of 1970 to 2004, although size of these appropriation and size of irrigated parcels may be smaller than pre-1970 agriculture developments.

Bitterroot River Watershed

The Bitterroot watershed covers the 2,814 square miles drained by the Bitterroot River above its confluence with the Clark Fork River.[27] The watershed is formed by the Bitterroot Mountains to the west and the Sapphire Range to the east. The lowest point in the watershed is defined by USGS gage 12352500 on the Bitterroot River near Missoula.[27] This watershed is also identified as Montana Hydrologic Sub-Basin 76H. The Bitterroot River is fed by the West Fork and East Fork above Darby. Painted Rocks Lake and Lake Como are the largest reservoirs in the watershed.

The 60-mile long Bitterroot Valley averages around 7 miles wide and covers an area of about 430 square miles. Running down the middle of the valley is the 1- to 2-mile wide floodplain of the Bitterroot River. Extensive high benches ranging from 3 to 6 miles in width run along the east and west slopes of the valley.[5] A map of the watershed is provided in Figure 3-6.

Figure 3-6

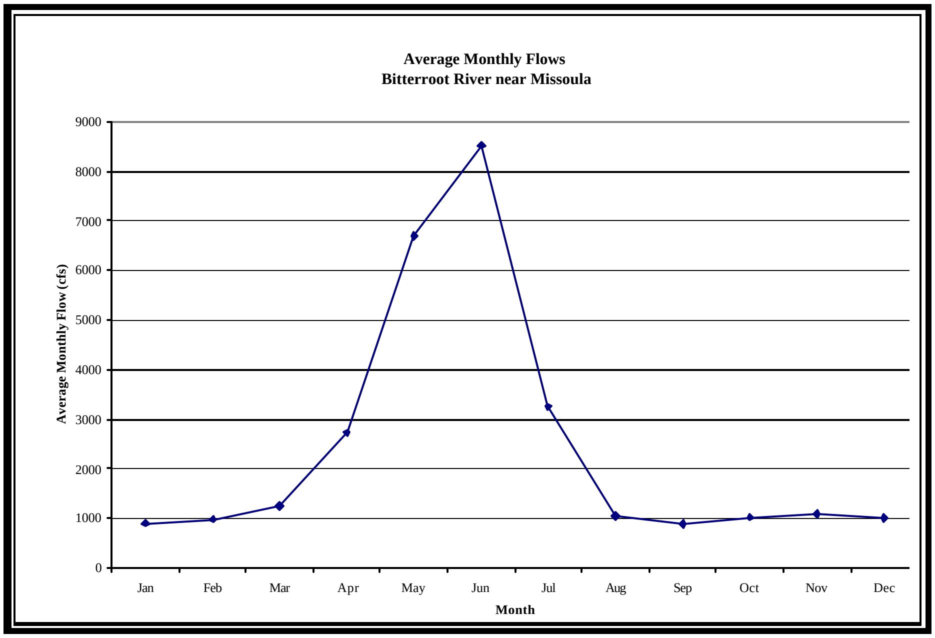


Physical Availability of Water in the Bitterroot River Watershed

Precipitation and Surface Water

Precipitation in this watershed averages 33 inches per year,[31] most of it in the form of snowfall, with greater totals in the higher elevation south.[5]. Streamflows leaving the Bitterroot River watershed average 2,193 cfs (1,584,881 acre-feet)[27] annually. Average monthly flows range from a high of 8,525 cfs in June to a low of 889 cfs in September. Figure 3-6 shows the average monthly flows in the Bitterroot watershed. Streamflows in the Bitterroot are regulated, in part, by Painted Rocks Lake and Lake Como. Both reservoirs are designed to supply water for irrigation, but also provide water for instream flows and recreational purposes.[5]

Figure 3-6
Average Monthly Flows in the Bitterroot River near Missoula



Groundwater

The Bitterroot Valley is a granite bedrock basin filled with predominantly tertiary sediments. Major groundwater supplies come from some surficial alluvium aquifers and ancestral river deposits. The east-side benches also have some shallow aquifers that appear to be supplied largely by water leaking from irrigation canals.[29] Groundwater is of great importance in the valley as most of the population relies on wells for drinking water.[5]

The productivity of wells in the watershed varies significantly depending on the composition of the source aquifer. The glacial till and glacial-lakebed deposits found west of the Bitterroot River have low productivities, ranging from 7 to 55 gpm. Wells located on the benches, where new residential development has been highest, are also not highly productive. The fractured bedrock along the valley fringes does not present major aquifers. By contrast, wells tapping the permeable sands and gravels near the center of the basin are highly productive. A water supply well for the City of Hamilton, for example, produces 500 gpm. An irrigation well tapping the same deposits yields 900 gpm.[5]

Most of the recharge to the water supply aquifers in this watershed appears to come from flood-irrigated field and irrigation canal leakage.[5] This suggest that the loss of irrigation or increasing irrigation efficiencies by lining canals, replacing canals with pipelines, or switching from flood to sprinkler irrigation would have a negative impact to groundwater supplies in much of the watershed.

MBMG's Ground Water Assessment Program is in the process of developing a baseline assessment of the groundwater resources of the Bitterroot-Lolo area. This assessment will include information describing the hydrogeologic framework of the area, hydraulic characteristics of the aquifers, and aquifer recharge and discharge characteristics.

Existing Appropriations of Water in the Bitterroot River Watershed

The Montana water rights database indicates that as of 1998, there were a total of 8,143 water use appropriations issued within the Bitterroot River watershed, which is the greatest number within any watershed in the Clark Fork River basin. The numbers of appropriations by type of water use is presented in Table 3-12. According to the Johnson report,[16] the vast majority of water diverted and consumed in this watershed comes from surface water sources and is used for irrigation.

Diversionary Uses

Irrigation

The Bitterroot River watershed contains approximately 94,000 irrigated acres, representing approximately 20% of the irrigated acreage in the basin. Based on the assumptions presented in earlier in this chapter, if all of these acres were fully irrigated, then irrigation in this watershed would divert or pump more than 465,800 acre-feet and consume 234,000 acre-feet of water per year. Spread out over the irrigation season, this volume of water would translate to a flow of roughly 1,570 cfs in diversions and consume 785 cfs. It is important to note, however, that competition between water users in the basin is high, especially on the tributaries. Many farmsteads do not receive full service irrigation. A water commissioner is appointed every year on the Bitterroot main stem to ensure the deliveries of stored water. Through this process, it is not unusual for main stem users to receive less than full service water supply.

Table 3-12 Water Appropriations: Bitterroot

Purposes	Total	Ground water	Surface Water
Commercial	368	356	12
Domestic	10,360	10,223	137
Flood Control	1		1
Fire Protection	20	11	9
Fish Raceways	10	1	9
Fisheries	75	23	52
Fish and Wildlife	378	143	235
Geothermal	9	9	
Geothermal Heating	8	8	
Industrial	29	25	4
Irrigation	6,504	1,814	4,690
Institutional	97	56	41
Irrigation - lawn and garden	3,726	3,640	86
Municipal	60	47	13
Multiple Domestic	252	248	4
Mining	21	1	20
Other Purposes	35	28	7
Pollution Abatement	1	1	
Power Generation	10		10
Power Generation Nonconsumptive	4		4
Recreation	164	95	69
Storage	4		4
Sale	1		1
Stockwater	5,897	3,251	2,646
Wildlife	7	5	2
Wildlife & Waterfowl	52	29	23
Other	2	2	
Total	28,096	20,016	8,079

Municipal and Residential

The Bitterroot River watershed covers all of Ravalli County and a small portion of southern Missoula County. The valley contains a series of small cities and towns, including Lolo, Florence, Stevensville, Victor, Corvallis, and Hamilton. All together, just over 70,000 people live in the watershed. According to DNRC,[8] the per capita water use in this watershed is among the highest in the state, averaging 409 gpd in Missoula County and 456 gpd in Ravalli County. About half of the water withdrawn for municipal uses comes from groundwater and the other half from surface water sources. If all 70,000 people in the watershed used water at the rate of 430 gpd, then the municipal water use would total about 33,700 af per year, which translates in to a flow rate of approximately 47 cfs. DNRC records have nearly 11,200 domestic, multiple domestic, and municipal uses, 98% of which are supplied by groundwater developments.

Non-Diversionary Uses

Hydropower

There are no major hydropower facilities in the Bitterroot River watershed. However, like all of the watersheds in the basin, water consumption in the watershed will impact water availability at the downstream hydropower facilities on the Clark Fork River main stem.

Instream Flows

DFWP has not claimed Murphy Rights on any stream reaches within the Bitterroot River watershed. DFWP has claims before the Montana Water Court in the statewide adjudication on selected water bodies, and has Painted Rocks and Lake Como water under contract for instream flow. Three small leases have been approved and two are pending on tributaries for instream flow.

Water Available for Future Use in the Bitterroot River Watershed

People of the Bitterroot River watershed have been in conflict over water resources since the late 1800s. Changing populations, growth, and development have brought considerable transformation to both the land use and the culture. Such changes have often been divisive.[32]

Surface Water

About 55% of the runoff in the Bitterroot River occurs in May and June. During summer, withdrawals for irrigation significantly reduce summer streamflows in the Bitterroot River and some of its tributaries. In the northern portion of the watershed, downstream from Hamilton, some stretches routinely approach the minimum flows required to support fisheries. Irrigation return flows, however, tend to augment stream flows in the fall and early winter.[5]

Chronic water shortages in the Bitterroot Valley have led to a temporary basin closure. This means that all of the sub-basins within the Bitterroot River watershed are closed to new appropriations and new state water reservations for surface water. Sharrott Creek and Willow Creek, two tributaries of the Bitterroot River, have been closed by administrative rule.

Groundwater

The basin fill deposits in the center of the Bitterroot Valley appear to contain considerable groundwater. Studies suggest that up to 21 million acre-feet of water are available in this aquifer.[5]

Population growth is greatest on the benches along the fringes of the Bitterroot Valley. The aquifers on the benches are shallow, have low productivities, and appear to be supported by irrigation canal leakage. Changing land use from irrigation to residential use will reduce the need for irrigation canal diversions, which in turn will reduce canal flows and leakage and thus reduce aquifer recharge. This combination will likely lead to increasing conflicts among groundwater users in the valley fringes.

The basin closure in the Bitterroot does not apply to groundwater resources, but the Larson Creek area within the watershed has been designated as Controlled Groundwater Area.

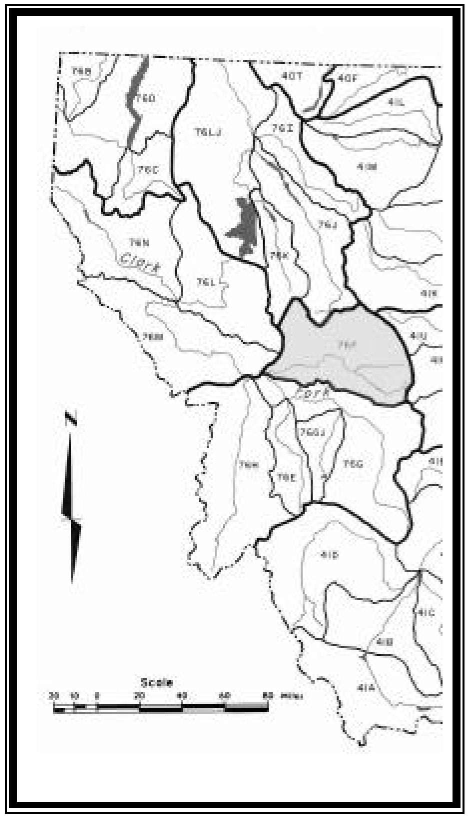
Demand for Future Water Use in the Bitterroot River Watershed

Municipal and Residential

The population of the Bitterroot Valley has been growing faster than any other watershed in the basin, averaging almost 3% a year over the past 10 years. Much of the population growth has been concentrated on the east and west benches on the sides of the valley.[5] The population of the watershed is currently over 70,000 people and is expected to continue growing into the foreseeable future. If the population continues to grow at its current rate, then the Bitterroot River watershed will have a population of over 91,000 people by the year 2020. At the high use rates exhibited in Missoula County (400 gpd), the added population would require an additional 9,413 acre-feet of water per year, which would translate into a flow rate of about 13 cfs.

Irrigation

Irrigation has been the dominant land use in the Bitterroot Valley. More recently, however, the growing population of the valley has led to subdivision and sale of historically irrigated acreages for residential uses.[5] These conversions have not necessarily reduced the lands under irrigation, but the size of the irrigated unit and the crops irrigated have changed. Estimating the projected demand for future water use by irrigation requires knowing the amount of irrigable lands remaining in the watershed. Data describing the irrigation potential of this watershed are not readily available.



Blackfoot River Watershed

Figure 3-7

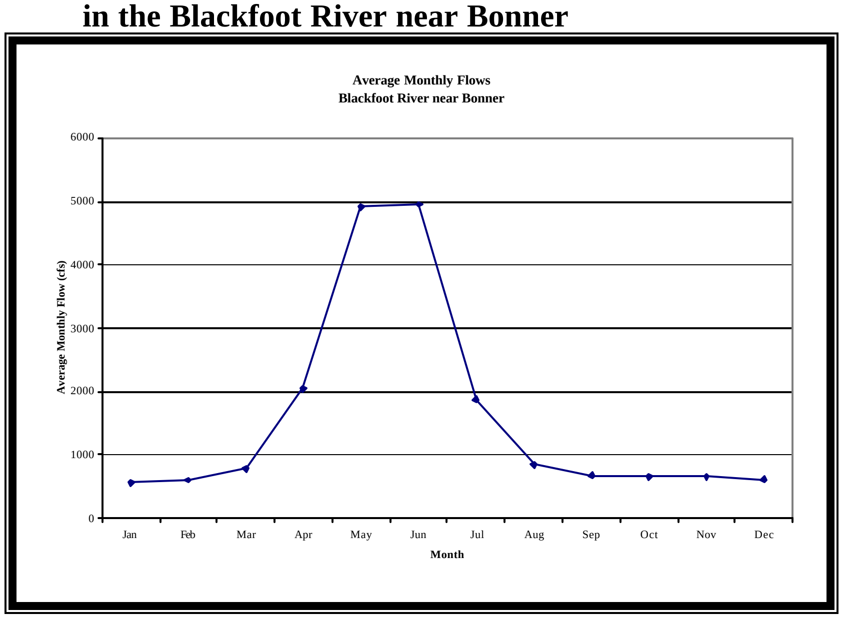
The Blackfoot watershed covers 2,290 square miles drained by the Blackfoot River above its confluence with the Clark Fork River. The lowest point in the watershed is defined by USGS gage 12340000 on the Blackfoot River near Bonner.[27] This watershed is also identified as Montana Hydrologic Sub-Basin 76F.[28] Major tributaries in the basin include the Clearwater River, the North Fork Blackfoot River, Landers Fork, and Nevada Creek. The watershed is also home to numerous ponds and lakes, including Kleinschmidt Lake, Lake Alva, Lake Inez, Seeley Lake, and Salmon Lake. A map of the watershed is provided in Figure 3-7.

Physical Availability of Water in the Blackfoot River Watershed

Precipitation and Surface Water

Precipitation in this watershed is averages just over 29 inches per year,[31] which is slightly greater than the average for the basin. Average annual flows leaving the Blackfoot River watershed are 1,573 cfs (1,136,807 acre-feet),[27] representing less than 10% of the flow in the Clark Fork at Noxon. Average monthly flows range from a high of 4,950 cfs in June to a low of 556 cfs in January. Streamflows at the end of the irrigation season (September) average 675 cfs. The average monthly flows are illustrated in Figure 3-8.

Figure 3-8 Average Monthly Flows in the Blackfoot River near Bonner



Groundwater

The Blackfoot watershed is topographically diverse, composed of several regions with different groundwater characteristics. In the lower part of the watershed, unconfined alluvium and glacial outwash are the primary aquifers. Groundwater from these aquifers is generally accessible at shallow depths and at yields ranging from 20 to 25 gpm. Glacial till deposits are extensive throughout in the lower part of the Watershed, but do not represent a major aquifer. Other geologic formations present in the area are capable of producing water, but generally have low productivity values. Wells located in fractured volcanic rock are capable of producing substantial amounts of water, but these highly productive fractures are difficult to locate. Fractured bedrock aquifers are not high yielding, but are usually capable of producing sufficient water for domestic use.

In the upper part of the watershed, shallow course-grained alluvial deposits form the primary aquifer. Alluvium within the tributary valleys tends to be less productive than near the Blackfoot main stem. Bedrock aquifers surrounding the valleys are quite variable in productivity, but some provide sufficient water for domestic use.[5]

Groundwater is an important resource in the Blackfoot River watershed because it is the sole or primary source of domestic and municipal water to most of the residents. More than 50% of the 3,500 groundwater uses are for domestic/municipal uses. Groundwater is also being used for lawn and garden irrigation and stock water. Traditional irrigation represents only 5% of the current developments.

Existing Appropriations of Water in the Blackfoot River Watershed

The Montana water rights database indicates a total of 6,450 water use appropriations in the Blackfoot River watershed. Surface water supplies 2,900 of these appropriations and groundwater nearly 3,600. The numbers of appropriations by water use category is presented in Table 3-13.

Although stock water represents the greatest number of water uses, the vast majority of the water diverted and consumed in the watershed is for irrigation, almost all of which comes from surface water sources.[16]

Table: 3-13 Water Appropriations: Blackfoot

Purposes	Total	Ground water	Surface Water
Commercial	78	69	9
Domestic	2,301	1934	367
Fire Protection	12	4	8
Fisheries	7	2	5
Fish and Wildlife	132	65	67
Geothermal	1	1	
Industrial	18	8	10
Irrigation	1,126	204	922
Institutional	6	6	
Lawn and garden	446	425	21
Municipal	6	4	2
Multiple Domestic	38	36	2
Mining	137	25	112
Other Purposes	6	3	3
Observation and Testing	7	2	5
Power Generation	7	1	6
Recreation	94	12	82
Storage	1		1
Stockwater	1,869	743	1126
Wildlife	143	28	115
Wildlife & Waterfowl	11	6	5
Other	6	5	1
Total	6452	3583	2869

Diversionary Uses

Irrigation

The Blackfoot River watershed contains approximately 44,280 irrigated acres. Based on the assumptions presented earlier in this chapter, if all of these acres were fully irrigated then irrigation in this watershed would divert close to 217,000 acre-feet and consume 80,486 acre-feet of water per year. Spread out over the irrigation season, this volume of water would translate to a flow of roughly 730 cfs in diversions and 365 cfs consumed. Although to a lesser decree, the Blackfoot is also seeing changing water user patterns. Of the roughly 450 irrigation water rights for irrigation of lawns and garden, 425 rely on groundwater developments. Four hundred of these lawn and garden developments occurred after January 1970. Only 94 groundwater sources were developed after 1970 to supply traditional irrigation.

Municipal and Residential

The Blackfoot River watershed covers portions of Lewis and Clark, Powell, and Missoula counties. Cities and towns in the watershed include Milltown and Lincoln. With a population of less than 6,000 people, the Blackfoot is the least populated watershed in the basin. The Montana water rights database indicates about 2,500 water rights for municipal and domestic uses, just over 2,000 of which are from groundwater.

Non-Diversionary Uses

Hydropower

There are no major hydropower facilities in the Blackfoot River watershed. The Blackfoot discharges into the Clark Fork River just above Milltown Dam. The small diversion dam near the river mouth behind Stimpson Lumber was used for power generation and other purposes. This dam is scheduled for removal in 2006-2007 as a part of the Super Fund cleanup of Milltown Dam. Milltown Dam is discussed in the Upper Clark Fork River watershed profile.

Instream Flows

DFWP has claimed Murphy Rights on two stream reaches within the Blackfoot River watershed. The reaches, priority dates, and period, flow and volume of these claims are presented in Table 3-14. In addition to these Murphy Rights, DFWP may have claims before the Montana Water Court in the statewide adjudication on selected waterbodies.

Table 3-14 Murphy Right Claims on the Blackfoot River (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Mouth to Clearwater River	1/6/71	9/1 – 3/31	650
		4/1 – 4/15	700
		4/16 – 4/30	1,130
		5/1 – 6/30	2,000
		7/1 – 7/15	1,532
		7/16 – 8/31	700
Mouth to Clearwater River	1/6/71	9/1 – 3/31	360
		4/1 – 4/30	500
		5/1 – 5/15	837
		5/16 – 6/15	1,750
		6/16 – 6/30	1,423
		7/1 – 7/15	848
		7/16 – 8/31	500

Water Available for Future Use in the Blackfoot River Watershed

Surface Water

Surface water is one of the most important natural resources in the Blackfoot River watershed. The Blackfoot River is classified as a Class I trout stream, and its waters are used extensively for irrigation and for instream uses, including wildlife habitat, fishing, and boating.[5] Upper basin water shortages have led to a permanent closure of the upper Clark Fork River basin, including the entire Blackfoot River watershed. The closure does not apply to stock water or water for storage for beneficial uses.

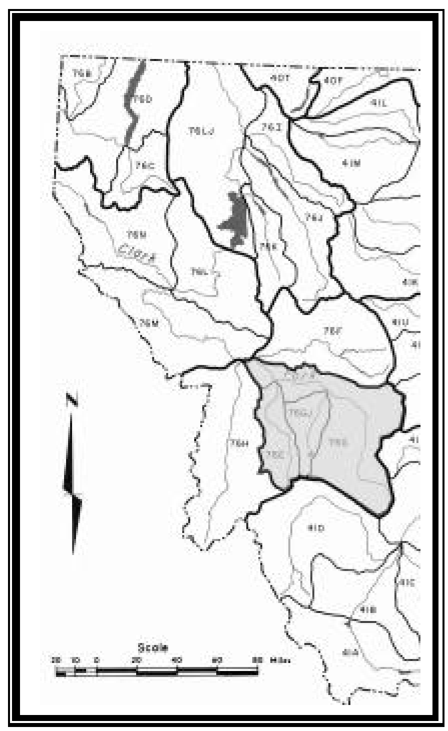
Groundwater
With a sparse population and most irrigators using surface water sources, demand on the groundwater resources in the Blackfoot River watershed has been limited. The basin closure does not apply to groundwater or water for domestic use. However, additional statutory criteria for groundwater appropriations do exist. An applicant proposing a groundwater appropriation in the Blackfoot and upper Clark Fork basin must submit a hydrologic report assessing surface and groundwater interactions. A project with an immediate or direct connection to surface water cannot be approved.

Projected Demand for Future Water Use in the Blackfoot River Watershed
Municipal and Residential
Population growth in the Blackfoot has averaged 1.3% a year over the past 10 years. If the population of the watershed continues to grow at its current rate, then it will have a population of 7,600 people by the year 2020. At the water use rates exhibited in Missoula County (400 gpd), the added population would require an additional 405 acre-feet of water per year, which would translate into a flow rate of about 1 cfs. Current trends indicate that the source of the additional water would be groundwater.

Irrigation
Currently the basin contains approximately 44,280 irrigated acres, almost all of which are irrigated from surface water sources. The projected demand for future water use by irrigation depends, in part, on the amount of irrigable lands remaining in the basin and the frequency of future droughts. Every year since 2000, Blackfoot water users have seen late season curtailment of irrigation and other consumptive uses as stream flows fell below the 700 cfs instream flow water right. These curtailments are an indication of limited surface water supply after runoff, especially in years with low snow pack. Data describing the irrigation potential of this watershed are not readily available.

Upper Clark Fork River Watershed

Figure 3-9



The Upper Clark Fork River watershed shown in Figure 3-9 covers 3,641 square miles. The lowest point in the watershed is defined by USGS gage 12334550 Clark Fork River at Turah.[27] This watershed is made up of three smaller hydrologic sub-basins: the Upper Clark Fork (76G) above Missoula, Flint Creek (76E), and Rock Creek (76GJ).[28] Major tributaries in the basin include Flint Creek, Rock Creek, Little Blackfoot River, and Warm Springs Creek.

Physical Availability of Water in the Upper Clark Fork River Watershed
Precipitation and Surface Water
Average annual flows leaving the Upper Clark Fork River watershed are 1,206 cfs (873,300 acre-feet), representing about 35% of the flow in the Clark Fork River at Noxon. Average monthly flows range from a high of 7,090 cfs in June to a low of 271 cfs in February.

Groundwater

Like much of the basin, the groundwater systems in the upper Clark Fork River watershed are generally characterized by a combination of basin fill aquifers on the valley floor with fractured bedrock aquifers at the valley fringes. In the upper Clark Fork valley, basin fill aquifer systems provide domestic water to almost all area residents, including the municipal supplies for Anaconda and Deer Lodge.

A study of irrigation return flows conducted by DNRC in the Flint Creek area[33] found that deep percolation from irrigation filled and maintained high water levels in the aquifer throughout the irrigation season. Groundwater levels drop after the irrigation season, reaching annual lows in winter. Return flow traveling through the aquifers was greatest during fall, but continued throughout winter. The timing of the return flow varies depending on the characteristic of the underlying aquifer. In full shallow aquifers, return flow occurs quickly and may be available to downstream irrigators almost immediately. In aquifers with greater storage capacity, return flow does not benefit the stream until later in fall, after the irrigation season. MBMG's Ground Water Assessment Program is in the process of developing a baseline assessment of the groundwater resources of the Upper Clark Fork area. This assessment will include information describing the hydrogeologic framework of the area, hydraulic characteristics of the aquifers, and aquifer recharge and discharge characteristics.

Table 3-16 Appropriations: Upper Clark Fork Basin

Purpose	Total	Ground Water	Surface Water
Agricultural Spraying	1	1	
Commercial	204	195	9
Domestic	4008	3852	156
Flow Through Fish Pond	1	1	
Fire Protection	15	10	5
Fish Raceways	10	3	7
Fisheries	11	5	6
Fish and Wildlife	80	14	66
Geothermal	2	2	
Geothermal Heating	3	3	
Industrial	126	63	63
Irrigation	2955	644	2311
Institutional	11	10	1
Irrigation - lawn and garden	1092	1073	19
Municipal	40	28	12
Multiple Domestic	77	74	3
Mining	204	61	143
Other Purposes	9	6	3
Observation and Testing	4	4	
Pollution Abatement	7		7
Power Generation	14		14
Power Generation - Non consumptive	1		1
Recreation	54	35	19
Storage	3		3
Stockwater	3096	1682	1414
Wildlife	55	23	32
Wildlife & Waterfowl	12	9	3
Other	6	5	1
Total	12,101	7,803	4,298

Existing Appropriations of Water in the Upper Clark Fork River Watershed

There are a total of just over 12,000 water use appropriations issued within the Upper Clark Fork River watershed. Some 7,800 hundred use groundwater supplies and nearly 4,300 rely upon surface water. The number of appropriations among water uses is presented in Table 3-16. Traditional irrigation supplied by surface water sources accounts for nearly 3,000 water uses, and domestic/municipal uses supplied by groundwater sources for just over 3,000 uses.

Diversionary Uses

Irrigation

The watershed includes approximately 121,000 irrigated acres, which represent less than 25% of the total irrigated acres in the basin. While most of the water supply for irrigation comes from surface water sources, groundwater supplies much of the irrigated acreage within the Missoula valley. Based on the assumptions presented earlier in this chapter, if all of these acres were fully irrigated, then irrigation in this watershed would divert nearly 592,900 acre-feet and consume close to 296,450 acre-feet of water per year. Spread out over the irrigation season, this volume of water would translate to a flow of roughly 1,990 cfs in diversions and 996 cfs consumed.

Municipal and Residential

The upper Clark Fork River watershed covers parts of Silver Bow, Deer Lodge, Powell, and Missoula counties, and all of Granite County. The largest cities in the watershed include Philipsburg, Deer Lodge, Anaconda, and Butte. The population totaled close to 58,000 people in the year 2002. Most communities in the watershed, including Missoula, derive their municipal water supply from groundwater. The exceptions are Butte and Philipsburg, which use surface water sources for their municipal water supplies.

Non-Diversionary Uses

Hydropower

Georgetown Lake was constructed as a hydropower facility and still has a water right for that purpose. However, it is not in operation and no longer has an active Federal Energy Regulatory Commission license. Ownership has been transferred to Granite County, which is pursuing a renewed license.

Instream Flows

DFWP has claimed Murphy Rights on two stream reaches within the upper Clark Fork River watershed. The reaches, priority dates, and period, flow, and volume of these claims are presented in Table 3-17. In addition to these Murphy Rights, DFWP may have claims before the Montana Water Court in the statewide adjudication on selected water bodies.

Table 3-17 Murphy Right Claims on Rock Creek (filed under SB 76)

Reach	Priority	Period	Flow (cfs)
Ranch Creek to Mouth	1/6/71	7/16 – 4/30	250
		5/1 – 5/15	454
		5/16 – 5/31	975
		6/1 – 6/15	926
		6/16 - 6/30	766
		7/1 – 7/15	382
Confluence of West Fork and Middle Fork to Ranch Creek	1/7/71	7/16 – 4/30	150
		5/1 – 5/15	454
		5/16 – 5/31	975
		6/1 – 6/15	926
		6/16 - 6/30	766
		7/1 – 7/15	382

Water Available for Future Use in the Upper Clark Fork River Watershed

Surface Water

Local water shortages have led to a permanent basin closure of the upper Clark Fork River basin above Milltown Dam. The Deer Lodge and Flint Creek valleys are intensely irrigated and water supplies are often limited. Historic stream reach decrees have controlled operations, especially during low water years, in these portions of the basin for decades. This watershed has several moderate-sized and many small storage reservoirs dedicated primarily to supplemental irrigation. The general consensus among basin residents is that storage of high spring surface flows may provide future water supplies.

Groundwater

The basin fill aquifers are generally productive and considered to contain abundant water. Return flows and artificial recharge driven by irrigation frequently have a significant role in groundwater supplies, especially in the tertiary sediments of Flint Creek and in the Deer Lodge area. The Rock Creek valley floor is narrow and constrained. The alluvial aquifer that underlies it is the primary source of water for most new developments, but its extent is limited. Local water quality problems have led to the designation of Warm Springs Ponds and Rocker groundwater areas as Controlled Groundwater Areas.

Projected Demand for Future Water Use in the Upper Clark Fork River Watershed

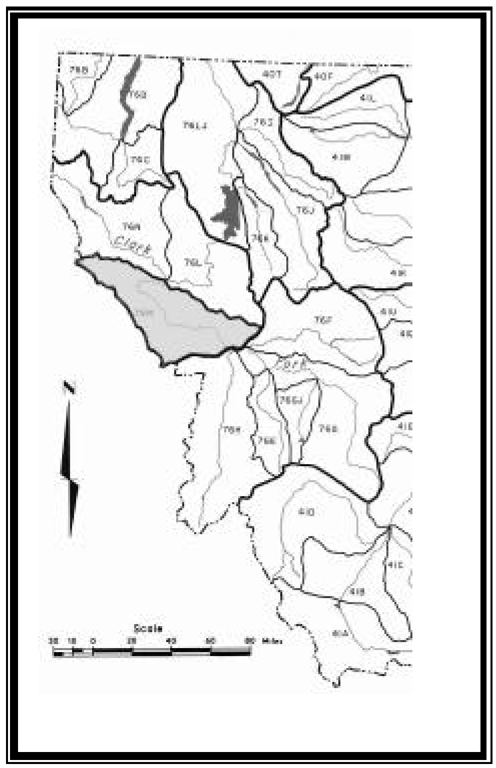
Municipal and Residential

Population growth in the upper Clark Fork River watershed has averaged about 1% a year over the past 10 years, with some areas growing at significantly higher rates. If the population continues to grow at its current rate, then the Upper Clark Fork River watershed will have a population of almost 68,000 people by the year 2020. At the water use rates exhibited in Missoula County (400 gpd), the added population would require an additional 3,113 acre-feet of water per year, which would translate into a flow rate of about 5 cfs.

Irrigation

Currently, the basin contains approximately 121,000 irrigated acres. The projected demand for future water use by irrigation depends, in part, on the amount of irrigable lands remaining in the basin and on the ability to store surface supplies or find hydrological unconnected groundwater. Water transfers, i.e., moving water to more productive lands, likely will be used for most new irrigation developments. Data describing the irrigation potential of this watershed is not readily available.

Figure 3-10



Middle Clark Fork River Watershed

The Middle Clark Fork River watershed encompasses 1,108 square miles. The lowest point in the watershed is defined by USGS gage 12354500 Clark Fork River at St. Regis.[27] This watershed is made up of a single hydrologic sub-basin—the middle Clark Fork..[28] The basin is formed by the confluence of the Blackfoot, Upper Clark Fork, and Bitterroot Rivers. Major tributaries in the basin include the St. Regis River and Ninemile Creek.

Physical Availability of Water in the Middle Clark Fork River Watershed

Precipitation and Surface Water

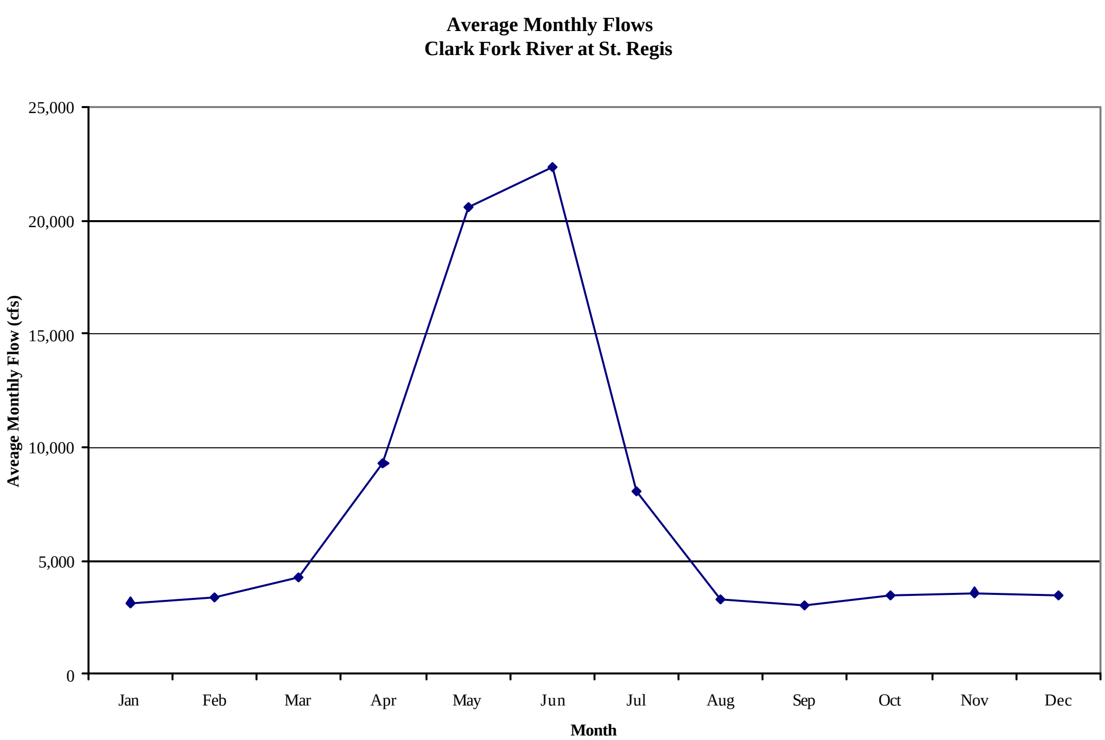
The high mountains on the west side of the watershed tend to form a rain shadow, the result of which is that precipitation in this watershed is the lowest in the Clark Fork River basin, averaging 28 inches per year. Average annual flows leaving the Middle Clark Fork River watershed are 7,352 cfs (5,212,290 acre-feet), representing about 35% of the flow in the Clark Fork at Noxon. Average monthly flows range from a high of 22,370 cfs in June to a low of 3,048 cfs in September. The average monthly flows are illustrated in Figure 3-11.

Groundwater

As is the case in the Upper Clark Fork River watershed, the groundwater systems in the Middle Clark Fork River watershed are generally characterized by a combination of basin fill aquifers on the valley floor with fractured bedrock aquifers at the valley fringes. The productivity of wells in this area ranges from 70 to 2,400 gpm. Wells in the bedrock are typically less productive but are generally sufficient to provide water for domestic use. Selected wells completed in bedrock aquifers are highly productive, with yields of 750 gpm.[5]

With reported yields as high as 2,300 gpm, the Missoula Valley contains one of the most prolific alluvial aquifers in the world. This aquifer provides water to most of the area residents, the Smurfit-Stone paper mill in Frenchtown, and thousands of acres of irrigation. It has been estimated that basin fill in the southern part of the valley contains about 8 million acre-feet of water. The sand and gravel aquifer underlying the City of Missoula has been designated a Sole-Source Aquifer by the USEPA. Close to 10 billion gallons are pumped from this aquifer each year. Mountain Water Company alone pumps up to 46 million gpd. By contrast, wells completed in the tertiary sediment and fractured bedrock at the valley fringes are of much lower productivity and are typically limited to domestic or stock water supply.[5]

Figure 3-11 Average Monthly Flows in the Clark Fork River at St. Regis



MBMG's Ground Water Assessment Program has developed a baseline assessment of the groundwater resources for most of the middle Clark Fork area while working on the Bitterroot Basin. This assessment includes information describing the hydrogeologic framework of the area, hydraulic characteristics of the aquifers, and aquifer recharge and discharge characteristics.

Existing Appropriations of Water in the Middle Clark Fork River Watershed

DNRC water rights records as of June 2004 include more than 10,000 water use appropriations issued within the Middle Clark Fork River watershed. Roughly 8,000 appropriations are supplied by groundwater and 2,000 by surface water. The number of appropriations by water uses is presented in Table 3-18 below.

Irrigation has the greatest number of water rights and is the greatest consumer of water in the basin, the vast majority of which comes from surface water sources.[16]

Diversionary Uses

Irrigation

This watershed contains approximately 16,800 irrigated acres, representing nearly 8% of the total irrigated acres in the basin. Most of the water supply for irrigation comes from surface water sources. Within the Missoula Valley, groundwater supplies most of the lawn and garden irrigation acreage. Four irrigation districts—Missoula, Hellgate, Orchard Homes, and Frenchtown—still service the Missoula Valley with active headgate and distribution systems. Based on the assumptions presented earlier in this chapter, if all of these acres were fully irrigated then irrigation in this watershed would divert nearly 82,320 acre-feet and consume close to 41,160 acre-feet of water per year. Spread out over the irrigation season, this volume of water would translate to a diversionary flow of roughly 280 cfs and 140 cfs consumed.

Municipal and Residential

The Middle Clark Fork River watershed covers parts of Missoula and Mineral counties. The largest cities in the watershed are Superior and Missoula. The population in the watershed is the largest in the basin, totaling close to 105,000 people in the year 2000. Most communities in the watershed, including Missoula, derive most of their municipal water supplies from groundwater.

Table 3-18

Purpose	Total	Ground Water	Surface Water
Augmentation	1	1	
Agricultural Spraying	2	1	1
Commercial	401	387	14
Domestic	4242	4088	154
Fire Protection	45	31	14
Fish Raceways	3	1	2
Fisheries	21	8	13
Fish and Wildlife	59	31	28
Geothermal	10	10	
Geothermal Heating	2	2	
Industrial	109	94	15
Irrigation	1652	689	963
Institutional	27	23	4
Irrigation - lawn and garden	1483	1458	25
Municipal	78	61	17
Multiple Domestic	168	165	3
Mining	105	8	97
Other Purposes	11	9	2
Pollution Abatement	1	1	
Power Generation	28	11	17
Recreation	104	27	77
Stockwater	1503	1072	431
Wildlife & Waterfowl	4	4	
Other	5	4	1
Grand Total	10,064	8,186	1,878

Non-Diversionary Uses

Hydropower

Milltown Dam, owned and operated by Northwestern Energy (formerly MPC), is the only major hydropower facility in the watershed. Milltown is a run-of-the river dam with a turbine capacity of 2,000 cfs, which is less than the average annual flow of the Clark Fork River at that point. Flows at this dam are affected by water uses in the both the Upper Clark Fork River and Blackfoot River watersheds. However, due to the long-term accumulation of mine-contaminated sediments behind the dam, USEPA has recommended removing both the contaminated sediments and the dam by 2006-2007. The clean-up plan includes restoring the river to emulate natural conditions.

Instream Flows

DFWP has not claimed any Murphy Rights in the Middle Clark Fork River watershed. Small instream flow leases have been established in the Ninemile Drainage.

Water Available for Future Use in the Middle Clark Fork River Watershed

Surface Water

Several tributaries to the Clark Fork River have been closed to most new surface water righter via administrative rule, including Grant, Houle, and Sixmile creeks. Tributaries within this basin are typically small and heavily appropriated, especially near Missoula. Many of these tributaries, such as Grant, LaValle, and O'Keefe creeks, also lose considerable flow as they move across the valley fill. The Clark Fork mainsteam has several large irrigation diversions in the Missoula valley, but these rarely cause allocation concerns for other uses. Below Missoula, the river becomes entrenched so that lift and pumping costs limit irrigation. Also, the valley floor is narrow, with a limited amount of potentially irrigable lands. Surface water supplies are either locally limited or constrained by downstream water demands—primarily hydropower.

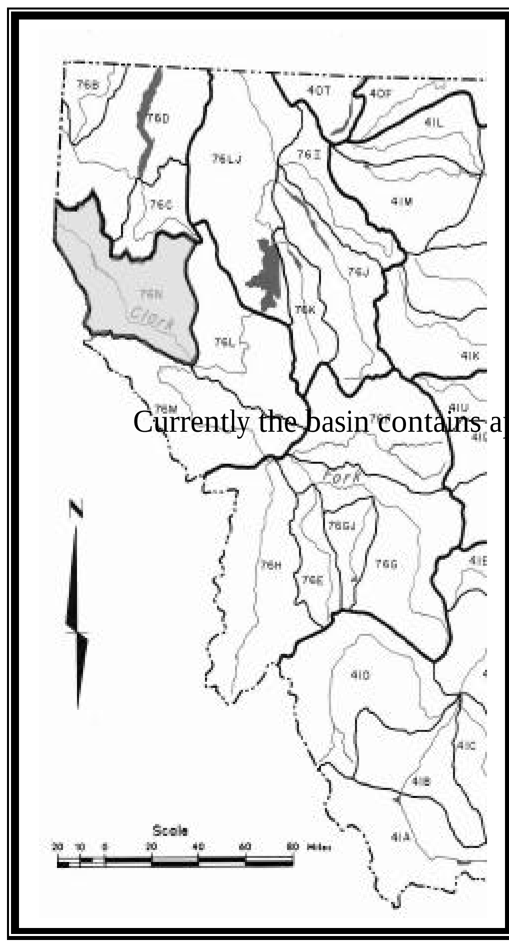
Groundwater

The basin fill aquifers are productive and considered to contain abundant water. Population growth, however, is increasing in the valley fringes where tertiary sediments and bedrock fractures must be used as water sources. Increasingly, residents are reporting inadequate water supply from these aquifers for domestic use.[5] Local water shortages or water quality problems have led to the designation of Hayes Creek as Controlled Groundwater Area. Local geology also limits groundwater development. Glaciated and faulted tributary valleys, such as Ninemile and Sixmile, can be extremely variable in their groundwater supplies. The glacial deposits are characterized by silts and clays with poor permeability inter-fingered with water-yielding fine-grain sediments.

Projected Demand for Future Water Use in the Middle Clark Fork River Watershed

Municipal and Residential

Population growth in the Middle Clark Fork River watershed has averaged about 30% during the 1990s, with some areas growing at significantly higher rates. If the population continues to grow at its current rate, then the Middle Clark Fork River watershed will have a population of almost 136,000 people by the year 2020. At the water use rates exhibited in Missoula County (400 gpd), the added population would require an additional 14,000 acre-feet of water per year, which would translate into a flow rate of about 19 cfs.



Irrigation

Currently the basin contains approximately

demands. Data describing the irrigation potential of this watershed are not readily available.

Lower Clark Fork Watershed

Lower Cl

The Lower Clark Fork River watershed is the most downstream watershed within the Clark Fork River basin before the river leaves Montana at the Idaho border. The lowest point of the watershed is defined by USGS gage 12391400 on the Clark Fork River below Noxon Rapids Dam near Noxon.[27] The watershed covers an area of 2,329 square miles, but at this point the Clark Fork River drains a total area of 21,833 square miles. This watershed is also identified as Montana Hydrologic sub-basin 76N.[34]

Major tributaries in the watershed include Thompson River, Prospect Creek, Trout Creek, and Bull River. This watershed is also home to a series of reservoirs formed by dams on the Clark Fork main stem. A map of the watershed is provided in Figure 3-12.

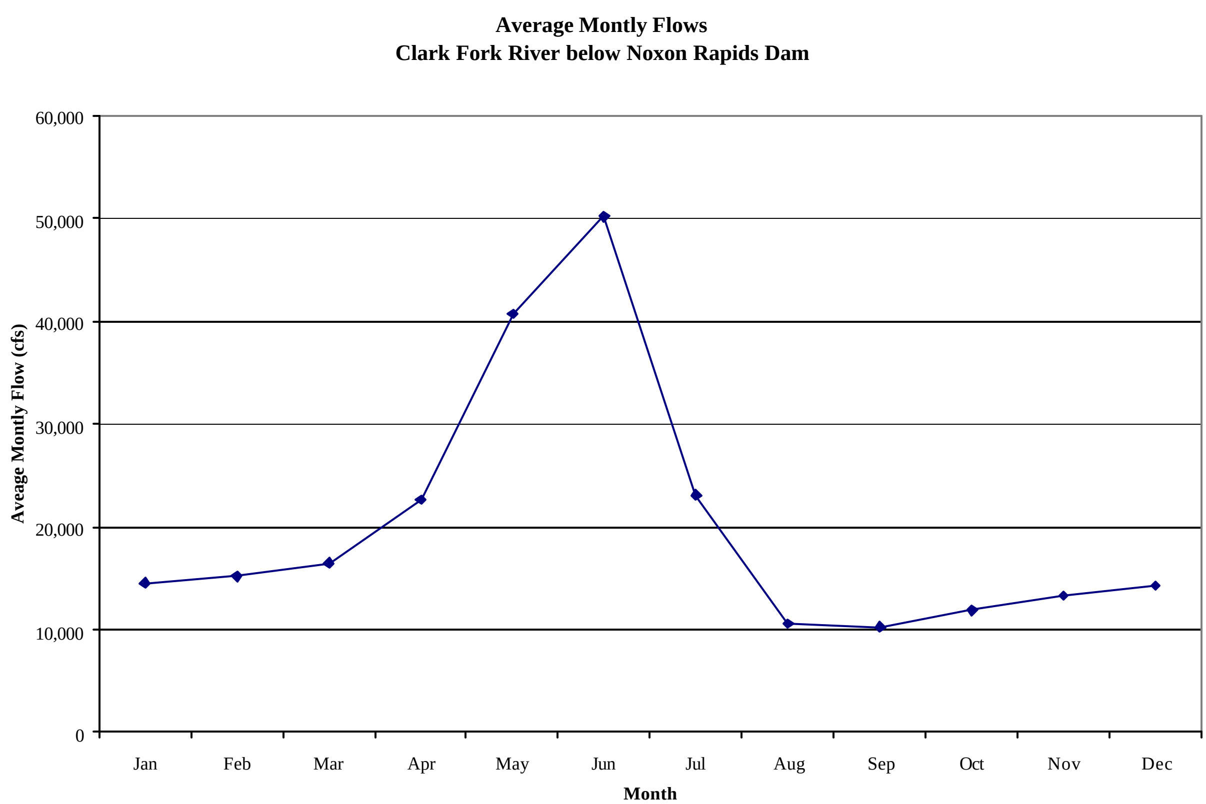
Figure 3-12

Physical Availability of Water in the Lower Clark Fork River Watershed

Precipitation and Surface Water

The relatively low elevation and western location of this watershed combine to amplify the humidifying effect of the Pacific air masses. The result is that precipitation in this watershed is the second highest in the Clark Fork River basin, averaging 36.79 inches per year. Average annual flows leaving the Lower Clark Fork River watershed are 20,504 cfs (14,818,240 acre-feet). The accretion of flows within the Lower Clark Fork watershed contribute 1.19 million acre-feet to the total outflow, after the contribution of the Flathead and Upper Clark Fork are deducted. This converts to an average annual flow of 1,644 cfs (and does not include Bull River, as the gage is located upstream of its confluence with the Clark Fork). Flows in the Lower Clark Fork are regulated by Kerr and Hungry Horse dams upstream in the Flathead River watershed, and by Thompson Falls, Noxon Rapids, and Cabinet Gorge dams on the Clark Fork River main stem.[5] Average monthly flows range from a high of 50,190 cfs in June to a low of 10,270 cfs in September. The average monthly flows are illustrated in Figure 3-13.

Figure 3-13 Average Monthly Flows in the Clark Fork River below Noxon Rapids Dam



<u>Groundwater</u>

Groundwater is an important resource in this watershed, supplying the domestic needs of almost all area residents, including municipal supplies for Thompson Falls, Trout Creek, Noxon, and Huron. The aquifer systems for these supplies are comprised of glacial deposits underlain and surrounded by bedrock. The glacial deposits are characterized by silts and clays with poor permeability inter-fingered with water-yielding fine-grain sediments. Productivity of wells in these aquifers can be as high as 1,500 gpm. Wells located near the river are hydraulically connected to the river and are affected by reservoir operations. Fractured bedrock aquifers in the valley fringes are of limited productivity, but can be used for domestic water supplies.[5]

Existing Appropriations of Water in the Lower Clark Fork River Watershed

A total of 4,380 water use appropriations have been issued within the Lower Clark Fork River watershed. The number of appropriations among water uses is presented in Table 3-19.

Domestic/municipal uses represent 50% of the total water rights in this basin. The largest number of surface water rights is for irrigation, and irrigation consumes the most water of any use in this Watershed. Power generation uses by far the most water by flow and volume.

Diversionary Uses

Irrigation

The Lower Clark Fork River watershed contains nearly 12,150 acres of irrigated land. Based on the assumptions presented earlier in this chapter, if all of these acres were fully irrigated then irrigation in this watershed would divert close to 56,000 acre-feet and consume 25,500 acre-feet of water per year. Spread out over the irrigation season, this volume of water would translate to a flow of roughly 170 cfs in diversions and less than 85 cfs consumed.

Municipal and Residential

The Lower Clark Fork River watershed is located entirely within Sanders County. Thompson Falls is the largest city in the watershed. The 2000 census indicates that 7,769 people live within this watershed. Most of the water supply for municipal uses comes from groundwater, but about 20% comes from surface water sources.[8]

Table 3-19

Purpose	All	Ground Water	Surface Water
Agricultural Spraying	9	7	2
Commercial	88	76	12
Domestic	2018	1748	270
Erosion Control	1		1
Flood Control	1		1
Fire Protection	22	8	14
Fish Raceways	4	3	1
Fisheries	12	3	9
Fish and Wildlife	53	8	45
Industrial	35	15	20
Irrigation	577	265	312
Institutional	4	4	
Irrigation - lawn and garden	539	492	47
Municipal	13	10	3
Multiple Domestic	70	68	2
Mining	7	3	4
Other Purposes	3		3
Observation and Testing	3	2	1
Power Generation	36	3	33
Recreation	29	4	25
Stockwater	846	572	274
Wildlife	1	1	
Wildlife & Waterfowl	11	5	6
Other Purposes	1	1	
Total	4383	3298	1085

Non-Diversionary Uses

Hydropower

The Lower Clark Fork River watershed is home to the Thompson Falls and Noxon Rapids dams and most of the reservoir behind the Cabinet Gorge Dam, which lies across the border in Idaho. The Thompson Falls dam, owned by PPL Montana, is a run-of-the-river facility and has a turbine capacity less than the average annual flow of the river. Avista Corporation owns Noxon Rapids and Cabinet Gorge dams. Flows from Noxon Rapids Dam immediately enter Cabinet Gorge reservoir.[2] Cabinet Gorge generates power and serves as a re-regulation reservoir for flows leaving Noxon.

Noxon Rapids and Cabinet Gorge dams have relatively recent water rights, but Noxon Rapids, with a turbine capacity of 50,000 cfs, is of sufficient size to utilize almost all river flows that occur at the site.[35] In addition, as of 1998, Montana water right records indicated that 7,805 (30%) of the 26,274 surface water uses in the Clark Fork River basin are junior to the earliest (1951) water right at Noxon Rapids Dam. Some 3,125

(12%) uses are junior to the latest (1974) Noxon Rapids water right. The uses with junior rights include 2,518 (32%) municipal, domestic, and other in-city uses, and 1,268 (16%) stock water uses.

Instream Flows

DFWP has claimed no Murphy Rights within the Lower Clark Fork River Watershed. DFWP may have claims before the Montana Water Court in the statewide adjudication on selected water bodies.

Water Available for Future Use in the Lower Clark Fork River Watershed

Surface Water

As with the larger basin, water availability in the Lower Clark Fork River watershed could be dictated by hydropower water rights at Noxon Rapids Dam.

Groundwater

With sparse population and few irrigators using groundwater, there appears to be little pressure on the groundwater resources of this watershed.

Projected Demand for Future Water Use in the Lower Clark Fork River Watershed

Municipal and Residential

Population growth in the Lower Clark Fork River watershed area has averaged 1.3% a year over the past 10 years. The population of the area is currently just over 8,800 people. If the population continues to grow at its current rate, then the watershed will have a population of over almost 10,000 people by the year 2020. At the water use rates exhibited in Missoula County (400 gpd), the added population would require an additional 530 acre-feet of water per year, which would translate into a flow rate of about 1 cfs.

Irrigation

Currently, the watershed contains few irrigated acres. The projected demand for future water use by irrigation depends, in part, on the amount of irrigable lands remaining in the basin. Data describing the irrigation potential of this watershed are not readily available.

Gaps in Information and Knowledge

The purpose of this water management plan is to (1) identify options to protect the security of water rights; (2) provide for the orderly development of water; and (3) provide for the conservation of water in the future. Though these tasks are largely a matter of policy, addressing them requires a foundation of information and knowledge describing the complex interactions among existing and potential future water uses and the water supplies they both tap and affect.

This section describes some of the gaps in information and knowledge encountered during the development of the watershed profile and the additional information and knowledge that would be useful to build the foundation for future basin planning and management efforts.

Physical Availability of Water

Precipitation and Surface Water

Precipitation data by sub-basin are readily accessible on-line through the NRIS Interactive Mapper system. Streamflow data are readily accessible on-line through the USGS.

Groundwater

Information describing the groundwater resources in the basin is only available for selected locations. It tends to focus on geologic development, with limited information available describing sustainable yields, flow patterns, influence of existing water users, and other information needed for the purposes of watershed planning and management.

MBMG continues to conduct studies and long-term monitoring programs in many areas of the basin. However, many of the monitoring sites are private wells, rendering their data less reliable. These wells were constructed for a purpose other than groundwater monitoring, and access to them is dependent on the voluntary participation of the well owner. MBMG says that insufficient data characterizing the volume, quantity, and flow patterns of the state's groundwater is hampering efforts to properly manage, protect, and develop groundwater resources.[29] MGMB would like to develop a groundwater monitoring infrastructure that contains dedicated monitoring wells with permanent access located in areas and at depths to best monitor and study the basins aquifers.[36]

It would also be useful if MBMG and others could evaluate the groundwater hydraulics of those aquifers underlying irrigated areas to better understand return flow patterns and quantities. Planning efforts would also benefit from estimates of sustainable yields from aquifers that are currently used. All information collected and developed should be made available on-line, perhaps by coordinating the effort of MBMG and NRIS.

<u>Surface water – Groundwater Interconnections</u>
Awareness is increasing that surface-groundwater interconnections are an important component of water management. These interactions need to be understood in order to evaluate water availability for new wells and the potential impacts of improving irrigation efficiency. Understanding the surface water-groundwater interconnection will require describing groundwater hydraulics for those aquifers affected by wells and irrigation. This understanding will likely require extensive field work and modeling efforts. Each watershed contains different combinations of aquifer systems, so the work would need to be repeated for each sub-basin, focusing on those areas with the greatest usage or potential impact.

Existing Appropriations of Water
Information describing existing appropriations of water represents the most significant gap in information and knowledge required for basin planning and management. The Montana water rights database currently contains information describing the water source type and name, location of the point of diversion, the type of water right, the purpose of use, the claimed flow rate and volume, the maximum irrigated acres (if applicable), the priority date, and the owner name. At this point, the adjudication process has not been completed anywhere in the basin and the information in the database varies in the level of review it has had. Most of the data have not been field verified. As a whole it cannot be considered to be accurate, consistent, and reliable. For these reasons, the water rights database is of limited use for evaluating existing water use and future water availability. For example, although it is possible to add up the numbers of water uses under each water use category for a given basin, it is not possible to accurately add up the total flow and volume of all existing water rights for a given period of use within a basin.

Some of the other challenges faced when using the database include the following:
- The claimed flows, volumes, and acreages are assumed to be exaggerated guesses.
- The majority of irrigation diversions are not measured or recorded.
- Data entry for such items as priority date, use codes, and flow units has not been consistent over the years.
- Period-of-use data are not accessible online and are not in a format that allows for data manipulation.
- A single point of diversion (POD) is likely to represent more than one place of use (POU).

- A single place of use may have more than one point of diversion.
- Multiple PODs are not cross-referenced.
- Irrigation efficiencies and return flows are not addressed in any way.
- Water leases are not identified.
- Instream flows for protection of native fisheries are not differentiated from diversions for private fish ponds developed for aesthetic and recreational uses.
- The database is not set up to allow for the type of queries needed for basin management without tremendous effort and extensive knowledge of the history of the database.
- The database is not yet fully connected to a GIS system. This represents a significant limitation to the usefulness of the data.
- Data describing historical water conflicts and objection to new water use permit applications are not readily available.

Basin water planning and management requires the ability to answer questions regarding the data contained in the Montana water rights database. To do this, information contained in the database would need to be verified and re-organized. The data need to be accessible electronically and online. The data need to be input or encoded to allow for sorts or queries. Any comments or special circumstances associated with the use should be included in a standardized fashion. Ideally, the database would be tied to GIS or other system that allows for spatial data manipulation. It should be possible to combine information from the database with other information such as streamflow data, to conduct modeling.

Diversionary Water Uses

Irrigation

Irrigation represents the single greatest consumptive use of water in the basin, yet data describing irrigated acreages, diversions, and consumptive uses of water by irrigators are inconsistent and unreliable. The correlation between flows, volumes, and acreages listed in the water rights database and actual flows, volumes, and acres irrigated is also unknown or inconsistent. Most irrigation diversion and water use estimates are based on combining estimates of numbers of irrigated acres with assumptions regarding irrigation scheduling, efficiencies, consumptive use, and surface and groundwater return flow timing and patterns. The combination of estimates and assumptions yields information that is of limited usefulness.

Gaps in irrigation information include the following:

- Data describing the numbers of historically and currently irrigated acres are not readily accessible.
- Data that are available vary widely depending on the source. These data are not connected to a GIS system.
- Data describing remaining irrigable acres are not readily available.
- Most water diversions for irrigation are not measured, so the largest consumptive use of water in the basin can only be estimated

Completion of the adjudication process would provide information describing the maximum entitlement but not actual water use associated with the irrigated acres and diversionary flows and volumes. Additional information would need to be collected to describe irrigation conveyance and application systems and to estimate irrigation efficiencies. Estimating return flows would require collection of information describing soils, groundwater systems, and groundwater hydraulics in those areas where irrigation occurs.

Residential and Municipal
Most large municipal diversions are measured. Many individual domestic uses are not measured. For the purposes of basin water management and planning, it is probably adequate to combine numbers of uses with estimates of per-capita or per-household consumption to estimate historical and current uses in this category.

Diversionary Uses
Hydropower
Information is available describing the claimed and actual water use by hydropower facilities in the basin.

Instream flows
Information describing instream flow uses are not readily accessible. Water leases are not identified in the water rights database.

Water Available for Future Use
Water availability involves more than hydrology. Legal and policy questions must also be addressed. The prior appropriation doctrine that underlies Montana's water right system will determine if water is available for additional appropriations. From a policy perspective, one must decide 'how much water should be left behind' as well as 'how much water is still there.'

Resolving issues involving water availability at a local level will require completing the adjudication process or, at a minimum, completing the examination process on all existing claims. This information will allow existing water use claims to be compared to existing water supplies to get a sense of the actual level of appropriation of existing water supplies and then to evaluate water availability on a local level.

Water managers have come to recognize that water availability is no longer a local issue only. Cumulative impacts of numerous upstream water users can have significant impact to downstream water users. This issue is highlighted by the realization that virtually any new water user in the basin may have a negative impact to the water rights held by Avista Corporation at Noxon Rapids Dam. This situation may be true for senior water rights holders located throughout the basin.

Ideally, a GIS-based model (containing verified water use information) would be developed and used to illustrate and evaluate the impacts of and interactions among existing water uses and water supplies, then answer a series of what-if questions addressing potential future water uses. The information developed by such a model would also help in developing more objective policy and procedures regarding adverse impacts.

Projected Demand for Future Water Use
Irrigation Water Use
Planning for future uses would require knowledge of how much more irrigable land exists in each watershed throughout the basin and predictions regarding the potential for currently irrigated lands to be developed for residential use.

Municipal and Domestic Uses
Existing population projection techniques can be used to estimate the number of new residential and domestic uses that might occur in the basin. It will be important, however, to also predict where these new residential developments might occur and what sources of water may be available to them.

Recommendations for Closing the Gaps

Closing the information and knowledge gaps discussed above will require data collection and manipulation efforts, policy changes, additional studies, and, ideally, extensive modeling efforts. Below are lists of recommendations for closing the gaps.

It is strongly recommended that all data collection, development, and updating efforts result in databases that are connected to GIS-systems that are readily accessed and queried online through NRIS.

<u>Montana Water Rights Database</u>
The first priority would be to verify and re-organize the water rights database, including:
- Complete the examination process for all water rights claims;
- Standardize all data entries and modify formats as necessary to allow for data queries and manipulation; and
- Update the information contained in "Montana Water Use in 1980."

<u>Other Water Rights Issues</u>
- Encourage all water use diversions to be measured.
- Require measurement of flow and volume of diversions for all new water right permits and changes.
- Develop a policy and objective basis for evaluating adverse impact.
- Develop a policy and objective basis for evaluating water availability.
- Develop a policy for addressing return flows. Irrigation return flow are most important, but other consumptive uses also generate returns (municipal wastewater for example).

<u>NRIS</u>
As stated above, it is strongly recommended that all data collection, development, and updating efforts result in databases that are connected to GIS systems that are readily accessed and queried online through NRIS. NRIS is valuable tool for accessing information needed for water management in Montana, but development of the watershed profiles illustrated some deficiencies in the system. Some of these deficiencies can be addressed by the following:
- Greatly increase server capacity; and
- Increase query capabilities for existing and future databases. For example, allow a user to develop customized search areas.

<u>Studies</u>
The administration of surface water is understood, but groundwater is less controlled, defined, and understood. Acquiring more data regarding groundwater is crucial to future water management. In addition to data collection efforts, it is recommended that studies be conducted in each sub-basin or watershed to address the following:
- Develop a groundwater monitoring infrastructure that contains dedicated monitoring wells.
- Evaluate groundwater hydraulics for those aquifers in irrigated areas to better understand return flow patterns and quantities. This information could be part of the groundwater assessments being conducted by MBMG.
- Estimate sustainable yields from aquifers that are currently used. This information could be part of the groundwater assessments being conducted by MBMG.
- Make all information available on-line. Coordinate efforts of MBMG and NRIS.

References

[1] DNRC 1988. Draft EIS for Water Reservation Applications in the Upper Clark Fork Basin. Helena, MT.

[2] FERC, 2000. Final EIS Cabinet Gorge and Noxon Rapids hydroelectric Projects, Idaho and Montana. Washington, D. C.

[3] National Research Council of the National Academies, March 31, 2004 "Managing the Columbia River: Instream Flows, Water Withdrawals and Salmon Survival."

[4] DNRC, 1976. The Framework Report, Volume One. MT DNRC Water Resources Division. Helena, MT

[5] Kendy, Eloise. 1996. Geographic, Geologic, and Hydrologic Summaries of Intermontaine Basins of the Northern Rocky Mountains, Montana. USGS Water-Resources Investigation Report 96-4025. Helena, MT

[6] Ground Water and Wells in the Clark Fork River Basin. Tom Patton and John LaFave. Montana Bureau of Mines and Geology Ground-Water Assessment Program. (Power Point presentation)

[7] McLane, Mike. 1999. Development of Water Uses in the Clark Fork of the Columbia River Basin. DRNC. Helena, MT

[8] DNRC, 1986. Montana Water Use in 1980.

[9] NRCS – Montana. State of the Land – Water Resources (http://www.mt.nrcs.usda.gov/technical/sol/waterres.html)

[10] University of Montana Wildlife Spatial Analysis Laboratory. (early 1990s) Landsat images converted to a land cover data set (http://nris.state.mt.us/nsdi/nris/gap90.html)

[11] 1980 Level Modified Streamflow 1928 -1978 by Depletions Task Force Columbia River Water Management Group (1983) as cited in March 5, 1998, ? Draft Conditions on Washington Water Power's FERC License at Noxon Rapids, by DNRC, Water Resources Division.

[12] USDA Bureau of Reclamation, Bosie, 1997, "UCAO-Clark Fork / Flathead Basin Irrigated Lands. An interpretation of Landsat date developed between 1988 and 1991.

[13] Totaling the 166 records displayed on the report Clark Fork Basin Water Rights Greater than 5 cfs & Junior to Noxon Rapids Dam - Sorted by Basin by Priority (June 2, 1998) shows is 67,852 acres, however, there is significant double counting of irrigated acres with inclusion of several reservoir records and change of use authorizations.

[14] Merlin Nelson, NRCS, Bozeman, Montana Per. comm.

[15] Spratt, Marc. 2003. Upper Flathead Basin Preliminary Water Use Study, Flathead County, Montana. Prepared for Flathead Conservation District by RLK Hydro, Inc. Kalispell, MT

[16] Johnson, Howard E. and Carole Schmidt, 1988. Clark Fork Basin Project Status Report and Action Plan. Clark Fork Basin Project, Office of the Governor, Helena, MT

[17] Protecting Instream Flows in Montana. Case Study based on a brief report by the Montana Consensus Council (http://www.policyconsensus.org/casestudies/pdfs/MT_streams.pdf)

[18] Montana River Action (MRA). Murphy Water Rights (http://www.montanariveraction.org/murphy-water-rights.html)

[19] Montana Code annotated 85-2-316 (2003)

[20] Curt Martin, DNRC. Per. comm..

[21] McLane, M. 1999. A Proposal to Resolve Current and Future Water Allocation Issues in the Clark Fork River Basin. Prepared for the Negotiation team representing the State of Montana and Avista Corporation. October 15, 1999.

[22] Cunningham, A. B., M.L. Bultsma, and R. D. Boyce, 1988. Effects of Future Irrigation Development on Hydroelectric Generation in the Clark Fork River Basin. MSU-Bozeman.

[23] U.S. Bureau of Reclamation, 1988. Effects of Future Irrigation Development on Hydroelectric Generation in the Basin

[24] Holnbeck, S.R., 1988. Investigation of Water Availability for Clark Fork Basin above Noxon

Rapids Dam. DNRC, Helena, MT

[25] NRCS-Montana. Highlights of the 1997 National Resources Inventory (http://www.mt.nrcs.usda.gov/technical/nri/mthighlt.html)

[26] NRIS Interactive Mapper (http://nris.state.mt.us/mapper/ReportsASP)

[27] USGS Water Resources on-line Data. (http://waterdata.usgs.gov/mt/nwis/annual/)

[28] Maps of Montana. Montana Hydrologic Sub-basins. (http://nris.state.mt.us/nsdi/nris/subbasin.gif)

[29] Patton, Thomas, Larry Smith, John LaFave, MBMG. 2002. Ground-Water Resources of the Flathead, Lake Area: Flathead, Lake, Sanders, and Missoula Counties, Montana. Information Pamphlet No. 4. Butte, MT.

[30] Curt Martin, DNRC. Per. comm..

[31] Montana NRIS on-line Interactive Map Builder. (http://nris.state.mt.us/mapper/)

[32] Montana Watersheds, Watersheds and Landscapes, Bitterroot Water Forum. (http://water.montana.edu/Watersheds/groups/details.asp?groupID=3)

[33] Voeller, Terry and Kirk Waren, DNRC, 1997. Flint Creek Return Flow Study. Montana Bureau of Mines and Geology Open File Report 364.

[34] Maps of Montana. Montana Hydrologic Sub-basins. (http://nris.state.mt.us/nsdi/nris/subbasin.gif)

[35] U.S. Bureau of Reclamation, 1988. Effects of Future Irrigation Development on Hydroelectric Generation in the Basin

[36] LaFave, John. 2003 Montana Bureau of Mines and Geology. Personal communication.